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An analysis of NSC San Diego's Broadway compound and National City annex local delivery system.

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Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL
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THESIS

An Analysis of NSC San Diego's Broadway Compound

and National City Annex Local Delivery System

by

Larry Eugene Flohr

Thesis Advisor: Alan W. McMasters

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With the implementation of NISTARS and NAVADS which provide the Supply Centers with state-of-the-art automated warehousing, material handling, and document processing, the Navy has the real-time information and warehousing assets necessary for the development of an optimal local delivery distribution plan which will improve supply support to all Supply Center customers. Essential to the development of an optimal local delivery distribution plan is the development of an information base to use as a measurement standard. This

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An Analysis of NSC San Diego's Broadway Compound and National City Annex Local Delivery System

by

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With the implementation of NISTARS and NAVADS which provide the Supply Centers with state-of-the-art automated warehousing, material handling, and document processing, the Navy has the real-time information and warehousing assets necessary for the development of an optimal local delivery distribution plan which will improve supply support to all Supply Center customers. Essential to the development of an optimal local delivery distribution plan is the development of an information base to use as a measurement standard. This study analyzes Naval Supply Center, San Diego's local delivery system with the intent of determining onload and offload times for unit pallet loads, driving transit times to each customer site, and the volume of material delivered. The results of this analysis may then serve as a data base for the development of a truck scheduling algorithm to optimize personnel and local delivery vehicle assets.

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ACRONYMS AND ABBREVIATIONS

AMHS	Automated Material Handling System
AVS	Automated Vehicle Scheduling
BMHS	Bulk Material Handling System
CAL ICE	California Ice
CASREP	Casualty Report
CH	Chill Provisions
CRT	Cathode Ray Tube
DPDO	Defense Property Disposal Office
DOD	Department of Defense
DODMDS	Department of Defense Material Distribution Study
EDF	Enlisted Dining Facility
FFT	For Further Transfer
FFV	Fresh Fruit and Vegetables
FRZ	Frozen Provisions
FMSO	Fleet Material Support Office
GSK	General Stores Material
IG	Inspector General
IPG	Issue Priority Group
LBNSY	Long Beach Naval Shipyard
MCRD	Marine Corps Recruit Depot
MHE	Material Handling Equipment
MILCON	Military Construction
MTIS	Material Turned Into Store
MTR	Mandatory Turn-In Repairable
NAB	Naval Amphibious Base
NCA	National City Annex
NARF	Naval Air Rework Facility
NAS	Naval Air Station
NASM	Naval Air Station, Miramar
NASNI	Naval Air Station, North Island
NAVELEX	Naval Electronic Systems Command

NAVSTA	Naval Station
NAVSUP	Navy Supply Systems Command
NISTARS	Navy Integrated Storage, Tracking, and Retrieval System
NOSC	Naval Ocean Systems Center
NRFI	Not-Ready-For-Issue
NRMC	Navy Regional Medical Center
NSC	Naval Supply Center
NSCSD	Naval Supply Center, San Diego
NTC	Naval Training Center
PWCSD	Public Works Center, San Diego
PWRS	Prepositioned War Reserve Stocks
RFI	Ready For Issue
SER	Shore Establishment Realignment
SIMA	Shore Intermediate Maintenance Activity
SOAP	Supply Overhaul Assistance Program
SUPSHIPS	Supervisor of Shipbuilding, Conversion, and Repair
UADPS-SP	Uniform Automated Data Processing System-Stock Point
USCG	United States Coast Guard
VSP	Vehicle Scheduling Program

I. INTRODUCTION

From April 1975 to March 1978 a DOD Material Distribution System (DODMDS) study was performed with the purpose "to conduct an examination of the current DODMDS and recommend improvements which will support the Services' requirements effectively and economically in peace and under mobilization requirements" [Ref. 1:p. 1]. Specifically, the study was to analyze and determine:

1. the sources of material delivered to the distribution system,
2. the location and operation of the distribution facilities,
3. the customers served by the system,
4. the transportation links, both commercial and government, that connect the sources of supply, the distribution facilities, and the customers, including overseas customers [Ref. 2:p. 9].

In this author's opinion, three significant programs have taken place, or are in the process of being implemented, at the Navy's major stock points in Norfolk, Oakland and San Diego as a consequence of the DODMDS study. The first is a CNO directed transfer of the management and administration of the wholesale material function of the Naval Air Station (NAS) located in the geographical proximity to the Naval Supply Center (NSC). By combining the wholesale material function, economies could be achieved with personnel, equipment, and material assets. The Navy accomplished this transfer under the Shore Establishment Realignment (SER) restructuring action [Ref. 3].

The second significant action is the installation and implementation of the Navy Integrated Storage and Retrieval System (NISTARS). NISTARS is a major component of a warehouse modernization plan and is presently being installed at

the three major Navy stock points. As a state-of-the-art automated warehousing system, it will be a major step in meeting the DODMDS objective of "supporting the Services requirements effectively and economically". The stated objective of NISTARS is to "increase productivity by reducing the amount of manual labor and to increase responsiveness of the supply centers to the routine and emergency requirements of the U.S. Navy fleet" [Ref. 4:p. 1-1].

The third significant program is the implementation of the Navy Automated Transportation Documentation System (NAVADS). NAVADS is an automated management control, planning and documentation system designed to facilitate effective processing of material requirements from start of supply center processing to the delivery of the material to the consignee. Interfacing with the Uniform Automated Data Processing System - Stock Point (UADPS-SP) and NISTARS, NAVADS will provide management with increased control over shipment planning, consolidation, documentation and allocation of resources through visibility of his delivery requirements.

With the expansion of the responsibilities of the Naval Supply Centers to include wholesale support previously provided by the Naval Air Stations and with the implementation of NISTARS and NAVADS which provides the Supply Centers with state-of-the-art automated warehousing, material handling, and document processing, the Navy has the real-time information and warehousing assets necessary for the development of an optimal local delivery distribution plan which will improve supply support to all Naval Supply Center customers.

A. PURPOSE

The purpose of this thesis is to conduct a study of the local delivery distribution system at the Naval Supply Center, San Diego (NSCSD). Essential to the development of an optimal local delivery distribution plan is the establishment of an information base to use as a measurement standard. This study will include a material flow analysis of the current local distribution system from NSCSD to the local customers with the intent of determining onload and offload times for unit pallet loads, driving transit times to each customer site, and volume of material delivered to each customer site. The results of this analysis will provide times for each of the various elements of the local delivery function which will be used as a data base for the development of a truck scheduling algorithm to optimize personnel and local delivery vehicle assets.

A similar study was conducted by Allion and Tufts of the local delivery system at the Naval Supply Center, Oakland to determine the distribution of travel times, the time to perform non-travel functions, such as loading and unloading of material, and the average costs of delivery to the various customer sites [Ref. 5]. And, as a complement to this study, Eller and Moore conducted a pre-consolidation study of the NSCSD local delivery system in which they identified the local customer base and the volume of business each customer generated by an analysis of requisitions processed [Ref. 6].

B. METHODOLOGY

A field trip was taken to NSC San Diego to familiarize the author with the current local distribution system and the operating environment. A field trip was also taken to NSC Oakland to acquaint the author with the NISTAR and NAVAD systems being installed.

A review of pertinent literature was made and included NSCSD local delivery procedures, management reports and studies, NAVSUP and FMSO functional descriptions and interface requirement statements, other automated vehicle scheduling (AVS) programs, and Navy Postgraduate School theses pertaining to the subject area.

The data analysis concentrated on the data contained in NSCSD's Local Delivery Individual Production Reports (NSC-SD 5200/20) and Daily Dispatching Records (11ND-NSC-4640/4) for the month of July 1982. Reports for July were selected in order to provide the most recent data for analysis. These reports and records documented driver utilization, transit times, and the number of pallets delivered. A statistical analysis was then conducted of this aggregated data to determine the distribution of driver utilization times and volume of material delivered.

C. THESIS ORGANIZATION

Chapter I has presented the purpose of this thesis as well as the methodology employed. Chapter II describes the current local distribution system and material flow. Chapter III describes NISTARS and NAVADS, the requirement for a local vehicle scheduling algorithm, and other truck scheduling systems employed. Chapter IV presents the data generated from the Individual Production Reports and analyzes this data to determine transit times, pallet onload and offload times, and volume by customer sites. Chapter V presents the summary and recommendations.

II. NSC SAN DIEGO'S LOCAL DELIVERY SYSTEM

The purpose of this chapter is to describe the NSC San Diego local delivery system. After a brief functional overview, a description of the physical facilities, equipment, customers, delivery schedules, and procedures is provided.

A. BACKGROUND

The Naval Supply Center, San Diego, has as its mission "to provide supply and support services to assigned fleet units and shore activities" [Ref. 7:p. 1]. As the major stock point in the southern California region, it is responsible for the material and logistic support for fleet units located in the San Diego and Long Beach areas and ashore activities at NAS Miramar, NAS North Island, Naval Amphibious Base Coronado, Camp Pendleton, submarine support facilities at Point Loma, Naval Training Center, San Diego, and Marine Corps Recruit Depot, San Diego.

NSCSD is located in five separate physical locations. Each of these locations performs unique functions within the scope of the supply center's operations and each has its own material distribution requirements.

1. Broadway Compound

Broadway Compound functions as the administrative center and the warehousing site for all binnable material (except that aviation peculiar which is warehoused at NAS North Island Annex), frozen and chill provisions, and some bulk material. In addition, California Ice (CAL ICE), a commercial firm under contract to the supply center to store fresh fruit and vegetables, is located approximately one and a half miles southeast of the Compound.

2. National City Annex (NCA)

Because of its location adjacent to the piers, NCA is the staging area and consolidation point for fleet support. It is also the warehousing site for dry and non-perishable subsistence and bulk storage. With the completion of the NISTARS warehouse modernization project, all of the warehousing presently at the Broadway Compound will be transferred to NCA.

3. North Island Annex

North Island Annex functions as the Aviation Support Department of NSCSD and is located at NAS North Island. It is the warehousing site for wholesale aviation binnable and bulk material as well as the supply support activity for the Naval Air Rework Facility (NARF) North Island.

4. Point Loma Annex

Point Loma Annex functions as the supply and distribution point for bulk petroleum products. In this capacity, it has a negligible effect on the local delivery system for Broadway Compound and NCA and will not be considered in this analysis.

5. Long Beach Annex

Long Beach Annex is located between the Long Beach Naval Shipyard (LBNSY) and Long Beach Naval Station. It functions as a warehouse site for storage of repairable material for which LBNSY is the designated overhaul point and also stocks material frequently used by the shipyard. In addition to the warehousing function, it also provides a SERVMART and central receiving area for the ships and shore activities located at the Naval Station. Other than the SERVMART support, all other material support is provided

from NSCSD Broadway Compound and NCA. For purposes of this study Long Beach will be treated as a customer of the distribution system of the Broadway Compound and NCA.

Since Broadway Compound and National City Annex are required to provide material support to all of NSCSD's customers, whereas the other NSCSD locations have specialized support functions, the Broadway Compound and National City Annex local distribution system will be examined in detail.

B. PHYSICAL LAYOUT

The physical layout of NSCSD has a significant impact on the local distribution system. Having warehouses dispersed between two areas constrains the ability for load consolidation, necessitates double handling, increases intra-supply center transfer of material, and complicates any attempt to develop an integrated distribution system. To more fully understand the complexity of this problem, NSCSD's Broadway Compound and National City Annex physical layouts are described in the following subsections. These descriptions are intended to complement the information provided in the study conducted by Eller and Moore in their pre-consolidation analysis of NSCSD's material distribution system [Ref. 6].

1. BROADWAY COMPOUND

The Broadway Compound is situated along the water front in downtown San Diego. Supply Center functions performed at the compound include: receiving, material storage, data processing, inventory control, administration, local delivery, and local delivery central dispatching. Table I displays by building number the amount of storage space available and the type of material stored. Figure 2.1 is a map of the compound.

TABLE I

BROADWAY COMPOUND WAREHOUSE FACILITIES

BLDG NUMBER	STORAGE AREA (sq ft)	MATERIAL STORED
1	37,200	Bulk storage of active items. Pallet rack and bulk storage of inactive items. Bin, modular bulk, pallet rack storage of medical supplies.
6	10,300	Bulk storage active items. Bin and pallet storage of inactive items.
7	13,178	Freeze and chill provisions.
8	8,000	Flammable material.
10	13,916	Cleaning supplies and hazardous material.
11	13,440	Local delivery. Water cargo storage. Packing and Staging area. Bulk storage.
12	103,126	Bin and modular pallet rack storage of active items.
125	15,322	Bulk and pallet rack storage of office supplies, misc. items, and alcohol locker.

The first floor of Building 12 houses the centralized receiving and staging operation for the Supply Center, and the second floor serves as the SERVMART centralized receiving area. The second floor of Building 11 is the packing area for Building 12, and the first floor houses the staging and shipping operations.

With the exception of frozen provision issues from Buildings 7 and 9, most bulk material is staged in the compound area adjacent to the respective storage sites and then transported to the pier staging area in Building 11 by straddle truck or by a bulk material handling system (BMHS) transporter. (The material handling equipment employed in the local distribution system is described in more detail in a later subsection.)

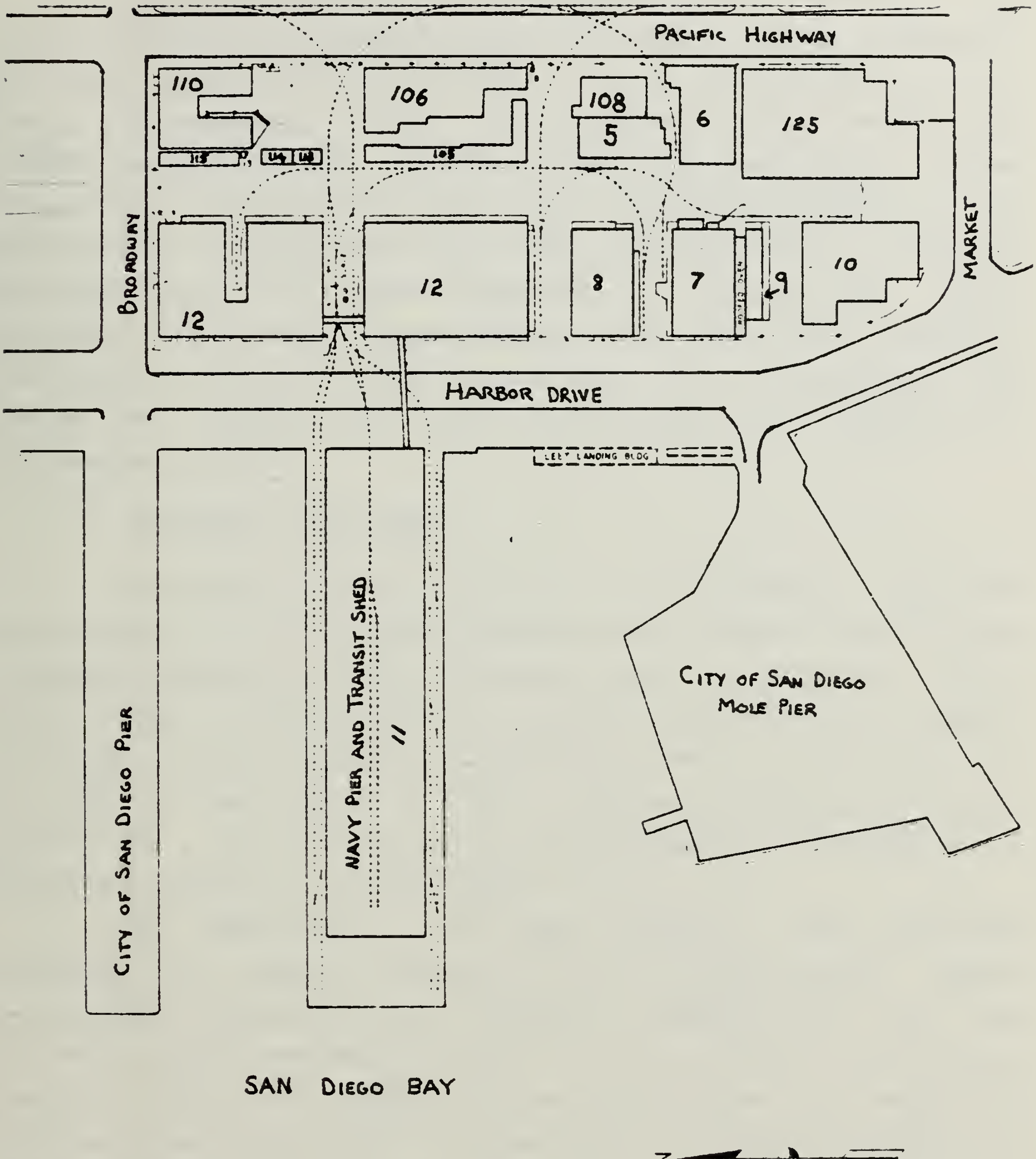

Figure 2.1 MAP OF THE BROADWAY COMPOUND

Binnable material is transported from Building 12 to the Building 11 packaging area by means of an automated material handling system (AMHS). This AMHS consists of a tote pan conveyor system which automatically queues the coded tote pans for consolidation and packaging. Upon completion of processing by the packaging section, the material is consolidated and then transferred to the pier staging area by freight elevators or forklifts. This material is further consolidated with the bulk material delivered from the other warehouses in the compound and staged for loading onto vans and trailers for delivery to customers or NCA.

2. NATIONAL CITY ANNEX

National City Annex (NCA) is located at the 32ND Street Naval Station, approximately four miles south of the Broadway Compound in the northern part of National City. NCA's primary function (75% as measured by volume of requisitions) is the support of the fleet located at the piers at the 32ND Street Naval Station. These piers are located within one and a half miles of NCA receiving and delivery sections located at Building 70.

In addition to the fleet support, NCA provides material and logistic support to all Naval Station shore activities including SIMA, SUPSHIPS, SERVMART and PWC, and to other NSCSD customers located in the southern California region. Table II displays by building number the amount of storage space available and the type of material stored in each. Figure 2.2 is a map of the annex.

Building P-014 in Figure 2.2 is the high rise warehouse with the automated storage crane retrieval system (ASCRS) which has added approximately 11,000 pallets of additional storage capacity to Building 66 for bulk pallet storage of dry provisions and clothing items. Not included

TABLE II

NATIONAL CITY ANNEX WAREHOUSE FACILITIES

BLDG NUMBER	STORAGE AREA (sq ft)	MATERIAL STORED
63	26,843	Pallet rack and bulk storage of clothing and overflow non-perishable subsistence.
64	15,099	Metal items.
65	27,000	Staging area for outbound cargo. NCA packing branch.
66	57,810	Dry provisions and bulk clothing.
67	24,952	Pallet rack and bulk storage of non-perishable subsistence.
68	27,456	Pallet rack and bulk storage of non-perishable subsistence.
69	26,496	Pallet rack and bulk storage of construction material.
70	27,000	Receiving and Local Delivery operation for NCA.
279	28,372	MTIS and SOAP material.
280	57,037	NRFI MTR's, wire, cable and gases.
317	5,120	PWRS pallet jacks and acid.
319	5,920	Packaged petroleum products.
322	44,026	RFI MTR's, clothing, classified equipment and publications, and photographic items.
P-033	180,000	Binnable and pallet rackable material (proposed).
P-035	32,000	Hazardous and Flammable material (proposed).

in Figure 2.2 is MILCON Building P-035 which is scheduled to become operational late in calendar year 1982. This warehouse will consist of 32,000 square feet of hazardous and flammable material storage. It is intended to be the warehousing site for that material presently stored in Buildings 8 and part of 10 and 125 at Broadway Compound. The building, annotated as P-033, is the high rise warehouse that will be equipped with NISTARS. It is intended to

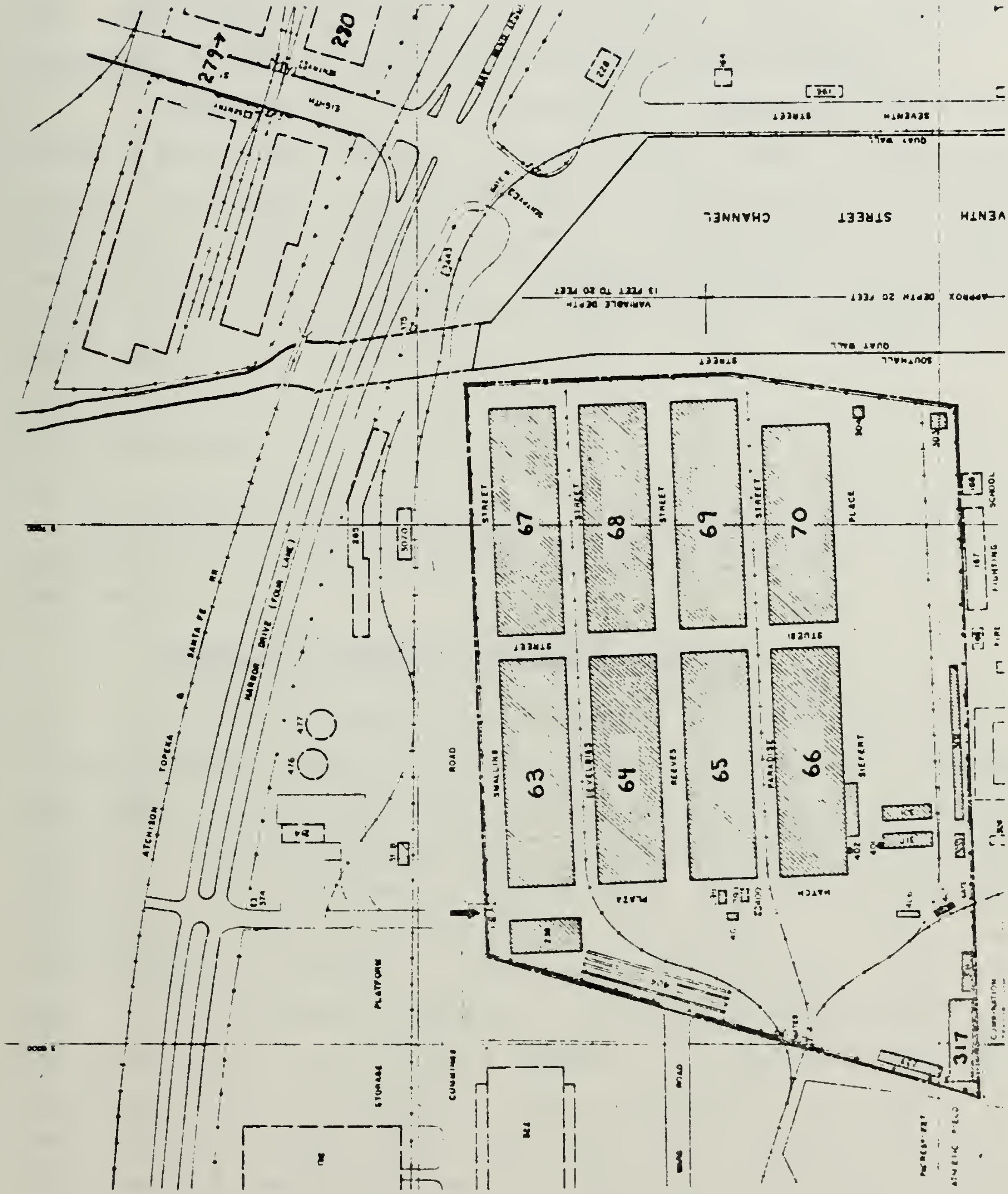

Figure 2.2 MAP OF NATIONAL CITY ANNEX

provide storage capacity for 85,000 binnable, 23,500 rackable, and 3,500 non-rackable items. When completed, it will warehouse the binnable, rackable, and the majority of the bulk material which is presently being stored in Buildings 1, 10, 12 and 125 at the Broadway Compound.

Building 70 is the central receiving point and staging area for delivery of material at NCA. Except for frozen and chill provisions which are delivered directly pierside to the ships, incoming material from Broadway Compound and from the North Island QUICKTRANS terminal is consolidated and staged at Building 70 for delivery to the customers.

C. EQUIPMENT

For purposes of this study, local delivery equipment is classified as either material handling equipment or motor carriers.

1. MATERIAL HANDLING EQUIPMENT (MHE)

Since the unit load is placed on the standard 40 by 48 inch wooden pallet, the MHE employed at Broadway Compound and NCA for material delivery are forklifts, straddle trucks, and BMHS transporters. The forklift is used extensively at both Broadway compound and NCA for loading and unloading of the motor carriers, relocating pallets, and positioning of pallets to facilitate handling by the other MHE. It is limited, however, in its ability to carry only one pallet (or two if double stacked) of material per trip. Therefore, the forklift is most effective when used for short trips in and around the warehouses, staging areas, and shipping and receiving areas. Forklifts are also provided to the ships to assist in offload of van deliveries of material from Broadway Compound or CAL ICE.

The straddle truck is another individually powered MHE which is used extensively at Broadway Compound and NCA for the handling of palletized material. When compared to the forklift, the straddle truck is not as flexible or versatile. However, with its capability to carry up to seven pallets, it is used primarily for making intra-compound transits. At the Broadway Compound, straddle trucks are employed in relocating palletized material from the various bulk warehouse staging areas to the local delivery staging area in Building 11. At NCA the straddle truck is also used for the relocation of material from the bulk warehouses to the delivery staging area. In addition, it is the primary means of delivery of material to the fleet, and other customers, located at the 32ND Street Naval Station. By eliminating the requirement to double handle the material in loading and unloading operations, forklifts are not required, and loading/unloading times are minimized. With its capability to carry up to seven pallets per trip, to self-load and unload, to travel relatively fast and to be relatively maneuverable, a straddle truck is well suited for the relatively long transit deliveries from the warehouses to the ships and the other activities located at the Naval Station. These trucks are, however, not authorized to travel on public highways and are limited to on- station use only. There are three straddle trucks in use at Broadway Compound and four in use at NCA.

The BMHS transporter, referred to previously in this chapter, is used to supplement the straddle trucks in transporting pallet unit loads. It is capable of carrying a maximum of twelve standard pallets, six per side. When used in conjunction with roller conveyors, it provides an alternative method to moving pallets the relatively short distances required between Buildings 11 and 12 at Broadway Compound. However, because of the age and material

condition of the two BMHS transporters and the fact that NSCSD has not invested sufficient resources in order to ensure efficient operational reliability, they are inclined to mechanical failure. One unit is presently being cannibalized in order to try to keep the other unit operational.

2. MOTOR CARRIERS

The primary mode of local material delivery from NSCSD to off-station customers is the motor carrier. Trucks and trailers used are obtained from two sources: commercial hire or rental from the Public Works Center. Prior to May 1979, NSCSD depended exclusively on its own personnel and equipment assets to haul transshipments and issues for local delivery and intra-supply center movements. However, in 1979 a NAVSUP Inspector General (IG) inspection team documented a problem of material loss and poor response times which were attributed to the large backlogs that existed in the local delivery system due in part to insufficent staffing (ie. ceiling point constraints). As a result, NSCSD received authorization from NAVSUP to utilize commercial drayage as a supplement to Navy assets [Ref. 8]. Since receipt of the authorization, contracts have been in effect with commercial firms to provide drivers, tractors and trailers to augment NSCSD assets in performing scheduled deliveries.

For the trucks and trailers rented from PWCSD, NSCSD provides its own drivers, schedules routine maintenance, and provides the fuel to operate them. Table III lists those motor carrier vehicles and equipment employed at Broadway Compound and NCA.

Deliveries of chill and fresh provisions from CAL ICE and frozen provisions from Broadway Compound Building 7 are normally conducted by 40 and 42-foot vans. Deliveries of GSK (general stores) type material is normally performed

TABLE III

LOCAL DELIVERY VEHICLES

NAVY VEHICLES
(rented from PWCSD)

TYPE	QTY
Truck, 1/2 ton Pickup	8
Truck, 5 ton Van	1
Truck, 5 ton Refrigerated Van	1
Truck, 2 1/2 ton stake	1
Truck, 7 1/2 ton stake	1
Tractor, 5 ton	5
Tractor, 7 1/2 ton	3
Tractor, 10 ton	5
Van, 32 ft	1
Van, 40 ft.	3
Van, 42 ft.	2
Trailer, 40 ft. Flatbed	22
Trailer, 35 ft. Lowboy	1
Trailer, 55 ft. Lowboy	1

COMMERCIAL VEHICLES

TYPE	QTY
Tractor, 7 1/2 ton	4
Trailer, 42 ft. flatbed	4
Stake Truck, 2 1/2 ton	2

using the 40 and 42-foot flatbed trailers except for pier deliveries to fleet customers. GSK pier deliveries are delivered to NCA Building 70 and staged for straddle truck delivery.

When issue time delays are acceptable, less than truck load quantities are staged and consolidated with other intra-area shipments at the supply center's respective shipping areas. Smaller trucks and vans are used when the requisition Issue Group necessitates immediate delivery and deliveries are less than pallet unit load. Examples of this are CASREPT, Hot Line, classified material, and signature-service-required deliveries.

The carrying capacity of the equipment listed in Table III varies according to vehicle size. In general, the 32, 40 and 42-foot vehicles can carry 14, 18 and 20 measurement tons or single stacked pallets. This is based on the assumption that the standard 40 by 48-inch pallet loaded with 40 cubic feet of material is equal to one measurement ton. The two lowboy trailers are not configured for carrying pallets and are used primarily for hauling outsized cargo.

All of the motor carriers are equipped with two-way radios with suffcient range that the dispatcher can contact them at all activities except Long Beach. The commercial carriers are provided with hand- held walkie-talkies. By requiring the drivers to report to the dispatcher periodically, the dispatcher is able to monitor their progress in the delivery route and modify the route if required.

D. CUSTOMERS

As the major Navy stock point in the southern California region for retail and wholesale logistic support of fleet and Naval shore activities, NSCSD has a potential of over 800 local delivery customers. Evaluation of the supply centers demand history file (DHF) tapes by Eller and Moore resulted in the identification of 352 local customers of which 188 were shore activities and 164 were afloat commands [Ref. 6:p. 57]. Most of these activities are located within the confines of military reservations. The afloat units are concentrated at either 32ND Street Naval Station (smaller surface ships), NAS North Island (carriers and LHA's), Point Loma (submarines and submarine tenders) and Long Beach Naval Station. Aviation units when not attached to a ship are located at Naval Air Stations at North Island or Miramar. Training units are located at the Naval Training Center, San

Diego. Submarine support units are located at Point Loma; aviation support units at North Island; and amphibious support units at Naval Amphibious Base Coronado. Marine units are located at Marine Corps Recruit Depot and Camp Pendleton.

Table IV lists the major customer concentrations and the distance in highway miles to these customers from Broadway Compound and NCA. The distances listed are based on highway mileage of the most direct route from Broadway Compound or NCA to the central receiving building of the major customer of each geographical area. Thus, the distances shown in Table IV may not be accurate for all activities located in that area. The actual distance to any one activity will be dependent on that activity's proximity to the designated major customer for that area. An analysis of Local Delivery Individual Production Reports indicated that the average transit time between activities within a geographical area was approximately five minutes. For purposes of developing a vehicle scheduling program, a five-minute transit time for multiple deliveries to a geographical area will be assumed for all activities except for vagaries as noted in Chapter 4.

The distance between NCA and Broadway Compound is approximately four miles if the most direct route south on Harbor Boulevard is taken. However, the route most frequently used, because it avoids the city traffic congestion and traffic lights, is the expressway, I-5. This distance is six miles. The difference in transit times between the two routes is negligible.

TABLE IV

MAJOR CUSTOMER CONCENTRATIONS

ACTIVITY	DISTANCE	
	BROADWAY CPD	NCA
Naval Station Long Beach	112	116
Camp Pendleton	38	42
NAS Miramar	13	17
Point Loma	5	9
NTC San Diego	4	8
NRMC San Diego	2	6
NAS North Island	7	6
NAB Coronado	7	6
Imperial Beach	13	9

E. DELIVERY SCHEDULES

In the issue and movement of material, it is necessary to identify the relative importance of competing demands for logistics systems resources. The Navy accomplishes this through the DOD Uniform Material Movement and Issue Priority System (UMMIPS). The priority of a requisition is determined by the urgency of need for the material (UND) and the requesting activity's assigned Force/Activity Designator (F/AD). As a guideline, requisitions with priority designators 01 through 03 are referred to as Issue Group (IG) 1 requisitions. For a requisition to qualify as an IG 1, the requirement must be immediate, and without the material, the activity is unable to perform one or more of its primary missions. Requisitions with priority designators 04 through 08 are IG 2 requisitions. For these requisitions the requirement is immediate, but the activity's mission is only impaired. Requisitions with priority designators 09 through 15 are routine and are referred to as IG 3. Table V displays the relationship between the priorities assigned to the requisitions and the UMMIPS time standards [Ref. 9]. These time standards represent the cumulative number of calendar days normally required for the functions listed.

TABLE V

UMMIPS TIME STANDARDS (Days)

	FUNCTION	TIME STANDARD FOR CONUS SHIPMENT BY PRIORITY DESIGNATOR		
		01-03	04-08	09-15
a.	Requisition submission (Note 1)	1	1	2
b.	Availability determination and storage site processing (Note 2)	3	4	13
c.	Transportation hold time and intransit time to requisitioner (Note 3)	3	6	13
d.	Receipt take up by requisitioner (Note 4)	1	1	3
	Total	8	12	31

Note (1) Requisition submission time is that period from the date of the requisition to the date of receipt of the requisition by the stock point.

Note (2) Availability determination and storage site processing is that period from the date of receipt by the stock point to the date that the material is made available to the Transportation Officer. This includes packaging and packing time

Note (3) Transportation hold time is the period from the date that the material is made available to the Transportation Officer until the date of receipt by the CONUS activity. This includes time required for containerization and consolidation.

Note (4) Receipt take-up time extends from the date of receipt of the material at the destination until the date that the material is recorded on the requisitioner's inventory records.

Monthly a transportation hold time report is generated as a measure of effectiveness of the Transportation Department. For a stock point to be 100% effective it would have to deliver the material to the customer within the UMMIPS established time frames for each requisition. However, the resources required to accomplish this may be cost prohibitive or result in a highly effective but inefficient operation. When there are only limited resources, such as manpower, vehicles or equipment, there needs to be a balance established between efficiency, when the material is

delivered at the least cost, and effectiveness, when the material is delivered within the minimum UMMIPS time standard.

In order to minimize the cost of trucks and drivers and still meet the established UMMIPS time standards, NSCSD has developed a weekly delivery schedule to its customers to satisfy their routine requirements and a Hot Line, Quick-Pik, and Hot Ship services to meet their urgent requirements.

The Hot Line Service processes IG 1 requisitions with the goal of delivering the material to the local customer within twenty-four hours (excluding weekends) after issue from the warehouse. The deliveries are accomplished by either two pickup trucks or NCA straddle trucks. Depending on zone delivery schedules, trucks hauling low priority material may also deliver Hot Line material to customers. Hot Line material for Long Beach area customers is delivered daily to the NSCSD Long Beach Annex.

The Hot Ship Service is a program to provide daily delivery service to those ships in the San Diego or Long Beach area that are scheduled to deploy within fourteen days.

The Quick-Pik Service is a program developed for processing high priority requisitions (priority 01-08) which the customer can pickup at NCA Building 306. It provides the customer with overnight service thus minimizing the disruptive effects of processing bearer walk-thru requisitions. Quick-Pik issues are delivered daily prior to 1300 to the pickup area.

Although most local deliveries are based on a weekly schedule, the actual number of trips and the times vary with the volume and priority of material to be delivered. This weekly schedule can be divided into two general categories. These categories are described in detail by Eller and Moore [Ref. 6:p. 69-75], and are summarized below:

1. Scheduled, Dedicated Trips. Those trips where both the frequency of delivery and the time when trucks are to depart from the Supply Center are published in advance. Table VI lists these trips by their frequency, departure times, destination, and type of cargo.

TABLE VI

SCHEDULED, DEDICATED TRIPS

FROM BROADWAY COMPOUND

FREQ	TIME	DESTINATION	CARGO
Daily	0330	Long Beach Annex	GSK
Daily	0830	NAVSTA SERVMART	GSK
Daily	0900	NCA Bldg 65	GSK
Daily	0900	NCA Bldg 70 for fleet	GSK
Daily	0930	NCA shore activities	GSK
Tues/ Thur	0400	Long Beach NAVSTA	FRZ/CH

FROM NATIONAL CITY ANNEX

Daily	0800	Broadway Compound	GSK
Daily	1000	NI Quicktrans	GSK
Daily	1300	NI Quicktrans	GSK

2. Semi-Scheduled, Dedicated Trips. The frequency of these deliveries is promulgated in advance. Therefore the customer expects delivery of material on a specific day, but does not necessarily know the time of day that it will be delivered. Table VII lists these trips by their frequency, destination, and type of cargo.

Those customer sites that do not generate sufficent volume of material delivery requirements to warrant dedicated runs are serviced by means of scheduled zone deliveries. Under this concept, material for several activities, that are in the same general geographic proximity, is

TABLE VII

SEMI-SCHEDULED, DEDICATED TRIPS

FREQ	DESTINATION		CARGO
2/Daily	32ND Street piers	(zones)	FRZ/CH
2/Daily	32ND Street piers	(zones)	FR
Daily	32ND Street piers	(zones)	GSK
Daily	NAS Miramar		GSK
Daily	NAS North Island		GSK
Daily	All shore activities	(zones)	GSK
Daily	NCA Bldg 70		GSK
2/Weekly	LBNSY		GSK
2/Weekly	NAS North Island afloat units		FRZ/CH
2/Weekly	MCRD		GSK
Weekly	32ND Street EDF		FRZ/CH
Weekly	NAS Miramar EDF		FRZ/CH
Weekly	Camp Pendleton		FRZ/CH
Weekly	NRMC Balboa		FRZ/CH
Weekly	NAS North Island EDF		FRZ/CH
Weekly	NAB Coronado		FR
Weekly	NAS North Island EDF		FR
Weekly	Camp Pendleton		GSK
Weekly	Imperial Beach DPDO		GSK

combined to minimize the requirement for delivery vehicle assets and is delivered based on a fixed weekly schedule. As shown by Table VII for those runs marked (zones), scheduled zone deliveries of GSK material and provisions are made to the ships at 32ND Street Naval Station. In addition, GSK material is delivered to the shore activities on a zone basis. Table VIII provides the weekly zone delivery schedule. Table IX is a list of the customers that comprise the various zones, and Figure 2.3 is a map of the zone locations.

By employing a zone delivery concept, delivery vehicle utilization is increased, but at the expense of increased delivery time to the customer. Material is currently delivered based on the zone schedule rather than as it is issued. In addition, the customer is unable to do any advance receipt planning or preparation because he has no assurance of receiving any material on a particular day's zone delivery. If the delivery vehicle is filled with material

TABLE VIII

WEEKLY ZONE DELIVERY SCHEDULE

ZONE	DAYS DELIVERED
1	Monday/Thursday
2	Monday/Thursday
3	Tuesday/Friday
4	As required
5	Monday/Wednesday
6	Tuesday/Thursday
7	Monday/Wednesday
8	Tuesday/Friday
9	As required

for other activities in the zone, the excess material will have to be delivered by supplemental vehicles or backlogged, awaiting delivery on a subsequent day.

F. CURRENT DELIVERY PROCEDURES

With the exception of the driver who performs the daily run to Long Beach at 0330, the local delivery drivers commence work at 0700 and secure at 1530 Monday thru Friday. They are authorized a half hour lunch break during the course of the day as their schedule permits.

Frozen and chill subsistence are preloaded daily in the refrigerated vans and are available for pickup upon arrival of the drivers. Loading of the vans for fresh subsistence does not commence until after receipt of the fresh provisions at CAL ICE from the local markets, resulting in frequent, inordinate delays in loading and subsequent delivery of these items. Dry provisions at NCA are prestaged for straddle truck delivery and are preloaded on trailers for those deliveries scheduled off station as time permits. Preloading of GSK material is done whenever workload permits. This is accomplished only after the next day's deliveries have been consolidated and staged.

TABLE IX

ZONE ASSIGNMENT CUSTOMER LISTING

ZONE NUMBER	LOCATION/ DESCRIPTION	NBR of CUSTOMERS
1,2,3,4	Afloat:	
	32ND Street Piers 1-13 and outer buoys	varies
5	Central:	
	32ND Street NAVSTA	19
6	Northwest:	
	Submarine support facility	
	Afloat	varies
	Ashore	4
	Marine Corps Recruit Depot	1
	Naval Training Center	8
	Point Loma area	5
	Others	
	Afloat	1
	Ashore	19
7	Northeast:	
	NAS Miramar area	17
	Air squadrons	6
	Naval hospital (NRMC)	1
	Others	10
8	National City South:	
	NAS North Island	
	Air squadrons	20
	Afloat	varies
	Ashore	18
	NAB Coronado	12
	Others	10
9	Broadway Compound shore units	5
	Camp Pendleton	
	Squadrons and groups	3
	Battalions	9
	Others	12
	Long Beach	
	Afloat	varies
	Ashore	11

The initial runs of the day are determined by the local delivery foremen at the respective sites. This is based on the priority of the material and known customer requirements. To aid in their decision making, the foremen are provided with Customer Service Department input identifying the "Hot Ships" (those soon to deploy), Issue Group 1 delivery requirements, and Quick-Pik documents. In

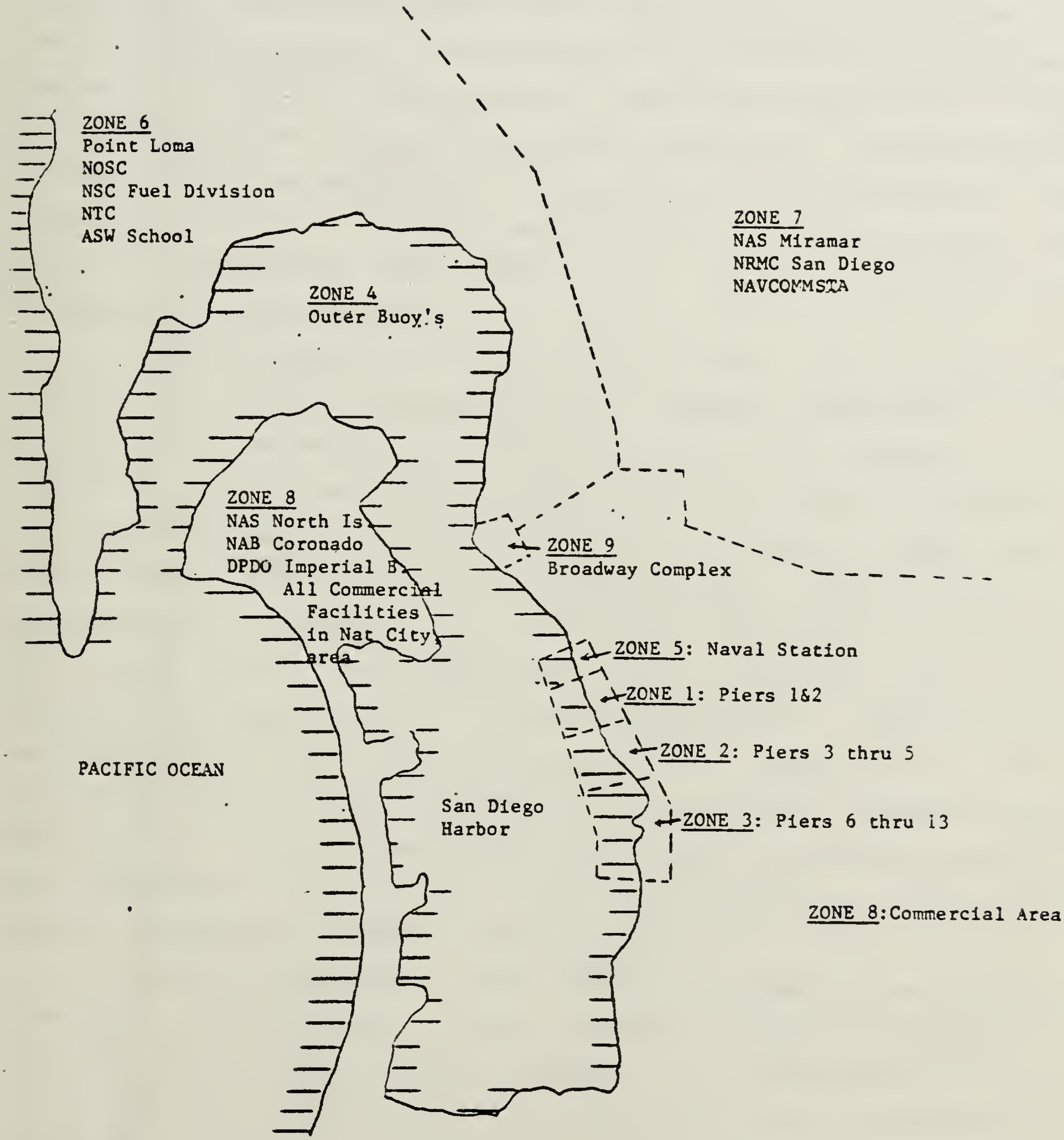

Figure 2.3 MAP OF LOCAL DELIVERY ZONES

addition, by surveying their respective staging areas, the foremen have visibility of the material staged for delivery that day and also that material which was not delivered as scheduled from previous days and is backlogged awaiting delivery. The initial runs are then allocated as driver and vehicle assets permit for delivery of scheduled and semi-scheduled dedicated deliveries. Shore activities can accept delivery anytime during the normal work day. Because ships usually want subsistence deliveries in the morning, the fresh, frozen and chill subsistence deliveries from the Broadway Compound and CAL ICE are given priority over delivery of GSK material.

After assignment of the initial runs, the foremen then advise the central dispatcher at Broadway Compound of the quantity of material by activity that still remains to be shipped. It is basically a "snap shot" of what is available for shipment as of that point in time. Based on this information and that which is provided by the Customer Service Department in regards to subsistence deliveries scheduled for that day, the dispatcher then prepares his Daily Dispatching Record with driver assignments. (Requisitions submitted by ships for provisions are required to cite a required delivery date to coincide with their scheduled zone delivery.) As a driver completes a trip, he reports back to the dispatcher via radio, and the dispatcher updates his Daily Dispatching Record accordingly.

As noted previously, GSK material issued from Broadway Compound for delivery to the ships at NCA is staged at Building 11. The Broadway foreman, in accordance with the zone delivery schedule and the Hot Ship list, forwards all material to NCA the day prior to its scheduled delivery for consolidation with NCA's issues for straddle truck delivery to the ships.

Because of the volume of material that is required to be moved daily to the fleet units and within the Broadway Compound and Naval Station, straddle trucks operate on a free flow basis and are not controlled by the dispatcher. The warehouse foremen at NCA and Broadway Compound are responsible for staging the material for the straddle truck pickups and in that manner control their movements.

During the course of the day, the dispatcher is advised of any additional emergency, or high priority requirements, that have developed and require resolution that day. His options include:

1. alter the route of a vehicle scheduled to make a delivery in that geographical area;
2. if the priority warrants and no other trips are scheduled to that activity, schedule a separate trip to satisfy the requirement;
3. defer the delivery to the next scheduled delivery or zone delivery to that activity on a subsequent day.

The dispatcher then determines the best method to satisfy these unscheduled requirements by considering the volume of material to be delivered, its priority in relationship to the priority of the material still awaiting shipment, what deliveries will have to be delayed and other factors that will affect the "cost" of making the delivery.

The Transportation Officer is responsible for the operation of the Transportation Division (Code 300). His control mechanism for monitoring the driver's productivity is the Local Delivery Individual Production Report (NSCSD 5200/20), (see Appendix A) which all truck drivers are required to document their activities during the course of the work day. This report includes information on loading delay time, loading time, the number of pallets loaded, transit time, offloading delay time, offloading time, and the number of pallets offloaded for each delivery. By reviewing these individual reports, the Transportation Manager is able to evaluate the performance of his drivers for that day. Since

there is no ongoing program to automate this data, it has only limited use for planning and scheduling in its present raw form. Efforts are presently being made to contract for the development of software for a minicomputer to allow processing the data from these reports into information that is usable by the Transportation Officer and his foremen in monitoring the performance of the men of the department.

The current local delivery procedures provide for a highly flexible, responsive system and are adequate when dealing with relatively small volumes of material and when there are more than a sufficent number of drivers and vehicles. However, the Transportation Officer and dispatcher are limited in their ability to efficiently manage the distribution of material because of:

1. large volumes of material,
2. inadequate visibility,
3. a general lack of the information required for planning and optimizing vehicle loading and truck scheduling.

With the implementation of NISTARS and NAVADS, the volume of material handled should decrease significantly through the elimination of the double handling requirement which now exists for the intra-supply center transfer of material from Broadway Compound to NCA for straddle truck delivery to the ships and Naval Station shore facilities. But more importantly, with the automated, real-time capabilities provided by NISTARS and NAVADS and the development of an automated local delivery vehicle routing and scheduling system, the Transportation Officer will now have a control system for operating and monitoring the local distribution system.

III. AUTOMATED VEHICLE SCHEDULING SYSTEMS

A. INTRODUCTION

The costs associated with operating vehicles and material handling equipment for local delivery purposes comprises a significant portion of a Supply Center's operating costs. Rental of non-passenger vehicles at NSCSD for FY-82 was budgeted at $531,000 [Ref. 10]. A small percentage savings in vehicle rental costs coupled with reduced labor costs, through reductions in overtime and reductions in commercial drayage charges, would justify efforts to improve the efficiency of the current local distribution system. These potential savings become even more significant when the stock point is confronted with escalating fuel, capital, and salary costs. However, as was noted in Chapter 2, efforts to improve efficiency must be carefully balanced against any adverse impact on effectiveness. With the Supply Center's primary function being the support of its customers, a change in the current procedures should consider the effects of the change on the support to the fleet and shore activities. For example, any attempt at consolidation of material into economical transportation units to achieve lower costs should be compared to the cost of increased Supply Center response time.

The use of analytic routing and scheduling models can be instrumental in improving the efficiency of a local distribution system and achieving these savings. With an optimizing analytic routing and scheduling technique, the Transportation Officer would be provided with a management and control tool for improving the effectiveness of his operation, as well as efficiency, which he previously did not have the capability to do.

In this chapter previous efforts at utilizing automated vehicle scheduling programs are described. In addition, the NISTAR and NAVAD systems will be described, and how they will impact on the local distribution system after implementation.

B. VEHICLE SCHEDULING PROGRAM (VSP)

VSP is an automated truck scheduling program that was developed by IBM and used by NSCSD in the 1970's. It had as its goals:

1. maximizing the loadout of vehicles,
2. minimizing the number of trucks (and drivers) required,
3. minimize the number of miles driven,
4. providing documented information with which to evaluate transportation system performance. [Ref. 11]

Originally developed for commercial use, multiple IBM 360 COBOL programs were written to adapt the VSP package to the NSCSD operation. However, due to saturation of the NSCSD computer, time to run the program had to be obtained from Fleet Accounting and Disbursing Center, Pacific (FAADCPAC), which was located in Building 12 at the Broadway Compound. The procedure was established to schedule the VSP package daily in the batch mode so that the schedules were available to NSCSD by 0630. In order to accomplish this daily run, input data had to be provided to the data processing facility at the completion of the day shift at 1530.

Based on conversations with the lead programmer for the project and with local delivery personnel, [Ref. 12:p. 12], the program was a workable, sound project with two major problems:

1. lack of positive management interest and
2. inaccurate information input.

Clausen, in his study of vehicle routing algorithms for Supply Centers, [Ref. 13:p. 33], contends that the major problem leading to the discontinuance of the VSP was the effort required in the daily collection of data. At the close of business each day, the warehouse foremen at Broadway Compound and NCA were required to determine the delivery requirements for the subsequent days' deliveries. This necessitated counting the pallets of GSK material for each activity staged at Broadway Compound and NCA awaiting the next days' delivery. This information was then manually coded for input into the VSP run. The only source of this information was obtained through actual physical counting of the pallets of material after they were staged. There was no automated method of determining the pallet space requirements of the individual line items at the time of issue. Since a second shift of warehousemen and drivers continued to stage and consolidate material after the foremen had submitted their counts to the data processing facility, the input data in many instances was understated.

Another data collection problem involved determining the number of pallets that could be carried on a trip. Unlike provisions where the units of issue are case lots and are easily stacked in a uniform manner to achieve a consistant pallet load, GSK material can be, virtually, an unlimited number of different sizes and shapes. Further compounding this problem was that some of the pallets can be double stacked, when loading a trailer or van, whereas others cannot. However, even when that was possible, a driver might decide he didn't want to carry stacked pallets. Therefore, the computer specified pallet count for a trip did not always correspond to what was actually loaded.

The VSP procedure was not flexible in that corrections or changes could not be made. The routing schedules generated each morning were fixed and any changes in volume or

location had to be manually scheduled or the data reinput and the program run again. By not having control over the operation of the IBM 360 computer, reruns of the scheduling program to reflect these changes were not feasible. When the IBM 360 computer was replaced, the decision was not to convert the VSP software to the newer computer system.

C. AUTOMATIC VEHICLE SCHEDULING (AVS)

Another automated vehicle scheduling system was the Automatic Vehicle Scheduling (AVS) program developed in 1979 by the David W. Taylor Naval Ship Research and Development Center. Unlike the VSP system, this system is interactive and designed for the Burroughs B3500 computers which are in use at the Supply Centers. The AVS system was designed to assist in scheduling of palletized cargo delivery among warehouses. It was tested and evaluated at NSC Charleston, S.C. in July 1981, and by April 1982, AVS schedules were being utilized on a part- time basis at NSC Charleston for a limited number of intra-center moves.

The dispatching problem at NSC Charleston is, however, different from that at NSCSD. At NSC Charleston there are 68 cargo pick-up/delivery sites located on the Naval Station, eight piers, and six off-base sites. Orders for processing are called to the warehouses on a batch basis periodically during the course of a day. When the orders are ready for delivery, the dispatcher is notified and he enters the order size (pallet count), originating warehouse and destination into the AVS program. Entries are made by filling in the blanks on a CRT screen. The dispatcher then inputs a discription of the vehicles available. With this information, the AVS program generates schedules for each vehicle based on the capacity of the vehicle, the origin and destination points, and a time constraint on the operation

of the vehicle. Those orders which are not scheduled for delivery are then backlogged for the following schedule. Orders ready for delivery can be entered into the program as they become available. In addition, a schedule can be modified to incorporate emergency orders (eg. Issue Group 1 requisitions) at the discretion of the dispatcher. Appendix B provides examples of routine schedule and revised emergency schedule outputs from AVS. These printouts are designed to be used as the dispatch schedules.

The AVS program has incorporated some features that were identified as deficiencies in the VSP program. By having the capability of running on the B3500 computer, Supply Center personnel have control of the time and the frequency of schedule generation. Recognizing that delivery requirements change during the course of a day, this becomes a very attractive feature. Also, AVS produces a history file for data collection and subsequent report generation of the number of pallets delivered, their source, destination, and backlogs.

A notable deficiency of the AVS system is the requirement to manually input the data necessary for schedule generation. Although this is accomplished by means of an interactive CRT terminal, it is a labor intensive effort. Because of the time required to input the data, the AVS program at NSC Charleston is only used for scheduling daily pickup and deliveries of approximately 75 to 100 pallets at out-lying, onbase warehouses. The volume of pallets processed through central receiving and high-issue warehouses precludes their manual input into AVS. Discussions with Mr. R. W. Farley, Transportation Manager at NSC Charleston, indicates that the system would be utilized on a full time basis for all local delivery operations if the data input problem could be resolved [Ref. 14].

Since the AVS system has only been used at NSC Charleston for limited on-base delivery of material, whether or not it can be adapted to the larger scale, local delivery environment at NSCSD has yet to be determined. However, delivery operations to the ships and shore support activities at NCA are analagous to that of NSC Charleston operations.

D. NAVAL INTEGRATED STORAGE TRACKING AND RETRIEVAL SYSTEM

NISTARS is a major warehousing system involving large scale warehouse modernization and automation. It is a state-of-the-art system both in process control and material handling. When the system becomes operational as scheduled in January 1984 at NSCSD, the impact on the local delivery system will be significant both in increased capabilities and the reduction in intra-center transshipment requirements.

1. SYSTEM SUMMARY

The center of operations for NISTARS will be Building P-033 with its computer controlled, warehousing system. It will be able to control virtually all aspects of the Supply Center's warehousing functions, including inventory of material, assignment of storage area, storage and retrieval of material in both the NISTARS and non-NISTARS warehouses, order accumulation, loading, and shipping. High turnover, binnable material will be stored in ministackers and will be automatically retrieved by the computer system. The low turnover, binnable material and all rackable material will be stored in shelves serviced by manned storage/retrieval machines (MS/RMs). Warehousemen will ride the aisles in special cabs equipped with computer terminals and printers and store/retrieve material as directed by the

computer. Material storage and issue in the other warehouses throughout the Supply Center (including North Island Annex and Broadway Compound) will be controlled by NISTARS through intelligent remote terminals (IRTs) or an interfacing system in the case of North Island's wire guided MS/RM system.

2. IMPACT ON LOCAL DISTRIBUTION SYSTEM

The impact on the local distribution system can be broken down into two general categories.

a. SYSTEM CONTROL

With NISTARS, management will have the ability to control which requisitions are processed, and which requisitions are suspended. In addition, management will be able to control the picking sequence and order accumulation. After the material is consolidated and packaged for shipment, it will be weighed and cube measurements will be taken. This data will then be forwarded to the NAVAD system.

b. OPERATION CONSOLIDATION

As noted in Chapter 2, with the implementation of the NISTARS and Building P-035 (hazardous/flammable) warehouses, the majority of that material presently warehoused at Broadway Compound will soon be warehoused at NCA.

This consolidation will eliminate the present requirement to dispatch vehicles from the Broadway Compound except to transport the frozen and chill provisions from Building 7 and fresh provisions from CAL ICE. Having all delivery vehicles originating from one location will give the dispatcher and Transportation Officer improved and control of their personnel and equipment. In addition, it will decrease the intra-supply center transshipment

requirement of GSK material between Broadway Compound and NCA. Eller and Moore estimated that 229,000 requisitions for binnable material with a weight of approximately 1,225,000 pounds was shipped from Broadway Compound to NCA during the period 1 January 1980 to 30 September 1980. [Ref. 6:p. 115]. Analysis of the Local Delivery Individual Production Reports for the period 12 through 16 July 1982 determined that 1350 pallets of material were intra-center transfers between Broadway Compound and NCA. The elimination of this transshipment requirement will have a significant impact on local delivery requirements.

Finally, having basically one point of origin for local delivery shipments of GSK material should simplify the decision making process for the dispatcher, Transportation Officer, and any vehicle routing/ scheduling algorithm.

E. NAVY AUTOMATED TRANSPORTATION DOCUMENTATION SYSTEM

NAVADS is an automated management control, planning and documentation system designed to interface with UADPS-SP and NISTARS in the preparation and shipment of material. It is intended to replace individual, local systems that have been developed by each stock point for shipment document preparation with a system that will standardize this process, make it more efficient, and also provide management with a shipment control and planning system. Through accomplishment of its objectives, NAVADS will:

1. relieve these labor intensive functions so as to improve documentation speed and accuracy,
2. conserve SDT (second destination transportation) funds through planning, shipment consolidation, mode and carrier selection,
3. meet UMMIPS timeframes. [Ref. 15:p. 4]

1. SYSTEM SUMMARY

NAVADS is designed to run on a Perkin Elmer minicomputer with data entry and output through CRTs and printers positioned at point of use. NAVADS is composed of five functional modules.

a. Basic Data Module

This module will be a data file for each item carried listing its respective weight and cube. This module will then interface with the other modules of NAVADS to provide the data necessary for the execution of their functions.

b. Management Control Module

This module will perform preliminary mode selection, carrier selection, airshipment clearance/challenge, preliminary shipment consolidation and management report generation. Through this module, management will have the ability to select free flow requisition/issue processing, batch processing, issue by IG, UIC, RDD, warehouse location or by some other selected parameter. Management will also have available operational reports which will highlight workload by consignee, warehouse area, or backlogs to which he will be able to match his work force.

c. Transportation Document Preparation Module

This module will automatically prepare most documentation required to label and ship material. Documentation will include: Government Bill Of Ladings (GBL's), Transportation Control Movement Documents (TCMD's), DD Form 1387 and 1387-1 Shipping Labels, and DD Form 1387-2 Special Handling/Certifications.

d. Transshipment Module

This module provides the Supply Center with the capability to trace transshipments from time of receipt of the material at the Supply Center to delivery to the customer. Tracking of the transshipment would be initiated by the receiving section inputing the document number, priority, weight and cube from the TCMD into NAVADS. Based on this data, the Transportation Officer, dispatcher and vehicle routing/scheduling program will have visibility of the quantity of transshipment material on hand by activity for inclusion in the local distribution system.

e. Local Delivery Module

As presently designed, this module provides the Transportation Officer with a manifest of the material designated as local delivery. Although originally designed to include a vehicle routing and scheduling algorithm, this function of the module is still under analysis and development by the Fleet Material Support Office (FMSO).

2. IMPACT ON LOCAL DISTRIBUTION SYSTEM

With NAVADS capability to provide "real time" cube and quantity information of both issued and transshipment material awaiting delivery, The Transportation Officer has increased visibility of his total local delivery requirements. He can utilize this information to plan and evaluate the local delivery system performance. By querying the NAVAD system for the volume of material available for delivery, the Transportation Officer will now have the ability to start planning his next day's operations rather than always being in a "reactionary" mode at the start of each workday. Unfortunately, as an aid to the development of a routing and scheduling algorithm, the information

provided by NAVADS has only limited application. Although cube information is provided for material awaiting delivery, this data cannot be simply aggregated and then directly correlated to pallet unit loads. Material characteristics such as outsized dimensions, packaging and handling peculiarities preclude determination of the number of standard pallet loads based solely on aggregated cube data. The number of pallets actually staged for delivery to an activity cannot be determined until the material has been consolidated for the final time. If, however, outsized cargo is treated on an exception/offline basis, NAVADS has the potential to be a useful medium for automated input of local delivery requirements data into an automated vehicle scheduling program.

F. SUMMARY

Automated vehicle scheduling programs for local distribution systems have been shown to be workable at Navy Supply Centers. The VSP and AVS program are two examples. A major deficiency in the systems used to date has been the inability to develop a method of automating the input of volume of material to be delivered. With the increased capabilities now provided by NISTARS and NAVADS, this problem may be solvable and an automated vehicle scheduling program may be practical for increasing the local delivery system's effectiveness and efficiency.

IV. ANALYSIS

In order to develop an automated local delivery routing/scheduling system, regardless of the algorithm used, there is some specific data required. Bodin, Golden, Assad and Ball determined that the data required for the classical vehicle routing problem are distances, customer demands, vehicle capacity, and fleet size [Ref. 16: p. 281]. In his analysis of vehicle routing algorithms, Clausen further expands on the specifications of data requirements. He also recognizes the requirement for data on distances, and contends that this can be equated to inter-customer times (transit times). In addition, data is required on the time to service each customer, that is, unload time and unload delay time, and the time to load each vehicle at the point of origin. The duration of a vehicle route will be the total of the transit time and the service time for each customer site. These times will be a function of how well the customer is equipped to unload the vehicle and the type of vehicle being used to make the delivery. [Ref. 13: p. 95].

In order to develop an automated vehicle routing/scheduling algorithm, these data requirements will have to be quantified. Chapter 2 began the process by identifying the fleet size and listed the respective capacities of the vehicles (see page 26). This chapter will continue to quantify the data requirements. Included in the discussion will be sections addressing the volume of material delivered (in terms of pallets) to the customer sites; transit times from Broadway Compound and NCA to the customer sites; driver non-transit, non-productive times (time required for loading and unloading delays and "other" non-productive functions,

for example, fueling of vehicles and safety meetings); driver non-transit, productive times (time required for loading and unloading of their vehicles); and a regression analysis of the number of pallets loaded and the loading time and number of pallets unloaded and the unloading time.

A. DATA DETERMINATION

The Transportation Officer is provided with a monthly report of Workload or Program Trends for his department. In addition to budget, manhour accounting, and vehicle utilization information, there is a monthly summary of the number of pallets handled by the local delivery system for the fiscal year. Table X is a report of the pallets delivered during the period October 1981 through July 1982. The quantities listed are the aggregated sum of pallets delivered as reported by the drivers on their Local Delivery Individual Production (LDIP) reports. This information is input daily into a minicomputer and then compiled monthly to produce the Workload or Program Trend report. While this report is useful in providing an insight into the magnitude of the local delivery task, it provides little information required for the local delivery planning process. There is no stratification of volume by customer site and no differentiation between straddle truck deliveries and motor carrier.

When Eller and Moore conducted their study, they attempted to utilize driver logs in an effort to quantify the volume of material delivered to customer sites. Two factors, however, led to their abandonment of this technique:

1. The data contained in the reports did not readily lend itself to automation and analysis, therefore, the desire to accumulate delivery statistics on all local customers could not be met with any reasonable sample size.

2. The head of the Transportation Division considered the accuracy of the data to be questionable. [Ref. 6: p. 80]

TABLE X

LOCAL DELIVERY WORKLOAD SUMMARY

PALLETS DELIVERED

OCTOBER 1981 THROUGH JULY 1982

MONTH	TOTAL	TO CUSTOMER	% OF TOTAL	WITHIN NSC	% OF TOTAL
OCT	43,860	22,226	51	21,634	49
NOV	39,111	19,929	51	19,109	49
DEC	44,789	21,529	48	23,257	52
JAN	43,562	20,192	46	23,370	54
FEB	44,020	19,407	44	24,613	56
MAR	57,628	27,641	48	29,987	52
APR	52,419	25,162	48	27,258	52
MAY	42,819	18,337	43	24,482	57
JUN	46,500	20,178	43	26,322	57
JUL	51,809	23,906	46	27,903	54
TOTAL	466,524	218,507		247,935	
AVG	46,652	21,351	47	24,794	53

Since Eller and Moore completed their study in mid-1981, NSCSD has replaced the daily driver logs with the more detailed LDIP reports. The format of this report varies from that of the driver log in that, in addition to the number of pallets delivered to a customer, the driver is required to record load/unload start and stop times for commencement of loading and unloading of the vehicle. Although the reports are prepared daily by the drivers with no mechanized control system to monitor their validity, the Transportation Officer states that, in his opinion, the data reported is reasonably accurate [Ref. 17].

Unfortunately, only the pallet unloaded count from the LDIP report is presently being input into the minicomputer. In order to obtain the information required for the automated routing/scheduling algorithm, it is necessary to develop a data base utilizing all of the data contained in the LDIP report.

For purposes of this study, the LDIP reports for July 1982 were selected because they were the most recent available and would be indicative of current operations. These reports were divided into two categories:

1. those reports of drivers of flatbed and lowboy trailers and vans (295 reports),
2. those reports of drivers of pickup trucks and stake trucks (99 reports).

This distinction was made because the trucks in category two are frequently used for less than pallet load deliveries, such as HOTLINE and signature-required items. In addition, because of their relatively smaller size, these vehicles are more maneuverable in the city traffic, around the warehouses, and the piers. It would be logical to assume that these vehicles would generally have shorter transit times and customer service times than the larger vehicles of category one. To include these reports in the analysis with the larger delivery vehicles would significantly bias the resultant transit times and on-site customer service times. Therefore, the LDIP reports in category two are not considered in this analysis.

In lieu of the LDIP reports, the straddle truck and transporter operators record their day's activities on a Compound Driver Performance Record. Because the record's abbreviated format only provided total pallet counts of material delivered during the day and did not differentiate between customer deliveries and intra-center transshipments, these records were also excluded from the analysis.

Of the 295 LDIP reports in category one above, 183 (62%) were analyzed. The 112 reports not analyzed from this category were excluded because:

1. they were illegible;
2. the author was unable to interpret the data as it was presented;
3. time did not allow the author to analyze every report, and, as a result, for those customer sites where a large sample base was already established, (a

minimum of thirty trips), additional reports were excluded from analysis (for example, frozen and fresh provisions to NCA ships and intra-center moves).

For purposes of this analysis, the average or arithmetic mean and median were selected as the measures of central tendency for the data. The arithmetic mean is computed by summing the value of the observations and dividing by the number of observations. The median is the observed data value above or below which lies an equal number of observations. The median is calculated from the data by sequencing the observations from lowest to highest, and then selecting the central value. Since the mean is influenced by extreme values to a much greater degree than the median, the median provides a better measure of central tendency than the mean when there are some extremely large or small observations.

NSCORE, or the normal probability plot correlation coefficient r, is a measure of the normality of the data. The more normal the distribution of the population, the greater the tendency for the data to yield near unity values (1) for the probability plot correlation coefficient r [Ref. 18:p. 112]. Therefore, a very high correlation is consistent with normality. The hypothesis of a normal distribution would be rejected if the NSCORE value falls below a critical value. The NSCORE value is a function of the number of observations in the sample and the level of confidence desired in accepting the normality hypothesis. Appendix C lists an abbreviated table of NSCORE values based on various sample sizes and confidence levels.

Standard deviations are used as a measure of dispersion of the observations about the sample mean. If the population has the form of a normal distribution, then approximately 68 percent of all observations lie within one standard deviation of the mean or average. Approximately 95.5 percent will lie within two standard deviations and 99.7 percent will fall within three standard deviations [Ref. 19:p. 58].

B. VOLUME OF MATERIAL DELIVERED

As noted previously, the quantities of pallets listed in Table X were aggregated quantities. Included in the category "within NSC" were intra-center motor carrier transshipments between Broadway Compound, NCA, and North Island Annex; intra-center straddle truck and transporter pallet movements; and QUICKTRANS pickup and deliveries.

Based on the data in the LDIP reports analyzed, Table XI provides a breakdown by customer site of the average quantity of pallets delivered per trip, the number of trips, the standard deviation, the median, and the NSCORE for that activity's sample observations.

A problem identified by Eller and Moore in their efforts to address the issue of volume of business by customer was the unit of measurement employed by the Supply Center [Ref. 6]. The Transportation Department uses the number of pallets handled as a workload measurement. Although the 40 by 48-inch pallet "theoretically" equals forty cubic feet or one measurement ton, not every pallet is stacked to that standard. Because of the irregularity of size and weight of individual line items, the majority of the pallets can be less than the standard. To compensate for the inflated counts that partially stacked pallets would provide, the drivers are required to estimate their pallet counts based on the forty cubic feet or the one measurement ton standard. There is some evidence that actual pallet counts instead of standard pallet counts are used. For example, it was reported that a 40-foot van made a delivery of forty-four pallets of chill provisions to the ships at NCA on 26 July. Another LDIP report stated that fifty-one pallets of frozen provisions were delivered to Long Beach on 1 July by a 42-foot van. This obviously exceeds the normal capacities of the 40 and 42-foot vans of thirty-six and forty

TABLE XI

PALLETS DELIVERED PER TRIP BY CUSTOMER

A. PALLETS DELIVERED FROM BROADWAY COMPOUND AND NCA

ACTIVITY	SAMPLE SIZE	TOTAL PLTS	AVG PLTS DLVD	STD DEV	MEDIAN	NSCORE	
CAMP PENDLETON	16	391	24.4	12.6	24.0	.963	
NASM	26	546	21.0	7.4	20.0	.981	
NRMC	23	337	14.7	12.9	8.0	.952	
LONG BEACH	11	306	27.8	14.2	31.0	.974	
POINT LOMA (SHORE ACTYS)	38	130	3.4	2.5	3.0	.845	*
POINT LOMA (SHIPS)	45	762	16.9	10.4	17.0	.986	
MCRD	15	232	15.5	11.3	14.0	.964	
IMPERIAL BEACH	15	433	28.9	7.2	32.0	.985	
NAB CORONADO	26	259	10.0	8.7	7.5	.971	
NTC	39	839	21.5	12.6	22.0	.988	
NORTH ISLAND ANNEX	33	457	13.9	9.1	11.0	.967	
NORTH ISLAND (SHORE ACTYS)	24	373	15.8	11.8	12.5	.956	
NORTH ISLAND (SHIPS)	34	497	14.6	10.6	12.0	.970	
NAVELEX	16	206	12.9	6.7	15.0	.967	
B. PALLETS DELIVERED FROM BROADWAY COMPOUND							
NCA SHIPS	36	752	20.9	12.4	19.5	.981	
NCA (NSCSD)	61	1129	18.5	8.8	19.0	.996	
NCA SERVMART	41	948	23.1	8.5	20.0	.978	
NCA MTIS (BDDG 279)	9	106	11.8	5.9	10.0	.974	
C. PALLETS DELIVERED FROM NCA							
NORTH ISLAND (QUICKTRANS)	46	1099	23.9	11.6	27.0	.984	
BROADWAY COMP FROM MTIS	13	255	19.6	6.6	19.0	.971	
BROADWAY COMP	52	965	18.6	6.8	20.0	.974	*
D. PALLETS DELIVERED FROM NORTH ISLAND							
NCA (NSCSD)	15	114	7.6	3.4	7.0	.874	*
NCA (NSCSD) FROM QUICKTRANS	30	763	25.4	10.5	25.5	.953	*
E. PALLETS DELIVERED FROM CALIFORNIA ICE							
POINT LOMA (SHIPS)	7	70	10.0	5.8	10.0	.994	
NCA SHIPS	15	257	17.1	10.1	18.0	.974	

NOTE: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

double-stacked pallets respectively. These inconsistencies in reporting the quantity of pallets delivered could be a factor influencing the large standard deviations shown in Table XI.

Another factor which may influence the large standard deviation in pallets delivered is the zone delivery procedure. Depending on the manner in which the delivery vehicle is loaded, there may only be space available for a partial load for some of the customers in the zone. As a result, the pallet count for a customer delivery may vary significantly from trip to trip.

In order to determine local delivery vehicle loading in terms of pallets onboard per trip, Table XII provides a listing of pallets delivered by zone rather than individual customer site. Zones one through four are excluded from Table XII because the LDIP report data did not specify by zone or pier the deliveries to the ships at NCA. Therefore, differentiation by zone could not be made.

A problem encountered in conducting this analysis by zone was the occasional combining of customers from different zones into one delivery. To include the data of a multiple-zone load in the analysis of a particular zone would tend to bias the results of any computation for average pallets delivered per trip. The results would be inflated if the multiple-zone loading was treated as a delivery to only the zone being analyzed. It would deflate the results if the pallets were allocated to their respective zones, and the zone being analyzed would be allocated its partial load. Therefore, multiple-zone loading records were not included in the computations for Table XII.

Of the thirty-two vans and trailers that were utilized in the reports analyzed, thirty-one of these had a normal load capacity of eighteen or twenty single-stacked pallets and thirty-six or forty double-stacked pallets,

TABLE XII

PALLETS DELIVERED PER TRIP BY ZONE

	SAMPLE SIZE	TOTAL PLTS	AVG PLTS DLVD	STD DEV	MEDIAN	NSCORE
ZONE 5 NAVELEX NAVSEA	13	219	16.8	7.4	16.0	.946
ZONE 6 NTC NOSC MCRD POINT LOMA	66	1684	25.5	8.8	26.0	.990
ZONE 7 NASM NRMC	29	705	24.3	8.3	24.0	.989
ZONE 8 NASNI NAB CORONADO IMPERIAL BEACH	69	1822	26.4	7.5	26.0	.986
ZONE LB LONG BEACH	9	273	30.3	15.0	37.0	.970
ZONE CAMP PENDLETON	15	367	24.5	12.5	32.0	.956

respectively. Therefore, based on the average pallet counts listed in the third column of Table XII, space on the vehicles appears to be reasonably well utilized. The closeness of the median and mean reinforces the NSCORE results that the average pallets delivered per trip has a normal distribution. It could also suggest that the vehicles are being loaded to the same extent and that the driver's estimates are consistent. It could also imply that specific drivers always make specific delivery trips.

Deliveries to a zone can be further stratified into vehicle type. This becomes more significant when analyzing loading and unloading times, because of the greater difficulty associated with unloading a van as opposed to a flatbed trailer. A flatbed trailer can be offloaded from both sides and the rear. A van can only be offloaded from

the rear. This becomes a more difficult operation where there are no loading dock facilities available to allow the forklift to drive in/out of the van. Fresh, frozen and chill provisions are normally delivered by van, whereas, GSK material and dry provisions are normally delivered by flatbed trailer. However, on occasion, GSK material will be used to top-off a van provision delivery. Table XIII lists the number of pallets delivered to the zones by vehicle type.

The flatbed trailers have a consistently higher average pallets delivered count by zone (zone 8 is an exception) and a lower standard deviation than the vans. This may be attributable to several factors. Since the flatbed trailer can be loaded from the sides as well as the rear, it is easier to load and thus is more condicive to double-stacking of the pallets. Since the vans are used primarily for delivery of frozen and fresh provisions which are generally considerably heavier than GSK material, a van may reach its weight limitations prior to utilizing all of its space. In addition, there may be an insufficient number of issues of provisions for a zone to fill the van, and, unless the driver is directed to top-off with GSK material, the delivery would be made with a partially filled van.

The only vehicle type utilized to make deliveries to Long Beach was the van. Since the average transit time to Long Beach is in excess of 153 minutes as shown in Table XIV, every effort is made to ensure that the van is fully loaded prior to its departure from NSCSD.

C. TRANSIT TIME TO CUSTOMER SITE

Transit time from the Broadway Compound and NCA to the customer sites is dependent upon the distance traveled and traffic conditions. Traffic conditions can be considered a

TABLE XIII

PALLETS DELIVERED TO ZONES BY VEHICLE TYPE

A. 40 and 42-FOOT FLATBED TRAILERS

ZONE	SAMPLE SIZE	TOTAL PLTS	AVG PLTS DLVD	STD DEV	MEDIAN	NSCORE
ZONE 5 NAVELEX NAVSEA	13	219	16.8	7.4	16.0	.946
ZONE 6 NTC NOSC MCRD POINT LOMA	54	1465	27.1	7.8	26.0	.992
ZONE 7 NASM NRMC	25	637	25.5	6.9	25.0	.977
ZONE 8 NASNI NAB CORONADO IMPERIAL BEACH	60	1574	26.2	7.0	26.0	.982
ZONE LONG BEACH	-	-	-	-	-	-
ZONE CAMP PENDLETON	9	248	27.6	11.4	36.0	.990

B. 40 and 42-FOOT VANS

ZONE	SAMPLE SIZE	TOTAL PLTS	AVG PLTS DLVD	STD DEV	MEDIAN	NSCORE
ZONE 5 NAVELEX NAVSEA	-	-	-	-	-	-
ZONE 6 NTC NOSC MCRD POINT LOMA	12	219	18.3	9.8	15.0	.965
ZONE 7 NASM NRMC	4	68	17.0	7.6	16.5	.965
ZONE 8 NASNI NAB CORONADO IMPERIAL BEACH	9	248	27.6	10.8	25.0	.983
ZONE LONG BEACH	9	273	30.3	15.0	37.0	.970
ZONE CAMP PENDLETON	6	119	19.8	14.9	14.0	.927

function of the time of day, the customer site location, and the weather. Weather and distances to the customer sites were constant during the period analyzed and were no influence on the variability of the data. Therefore, the time of day and the customer site locations remain as the basic factors affecting the variability of the transit times.

Table XIV lists by NSCSD points of origin average transit time in minutes per trip, standard deviation, median, NSCORE, and sample size from which the computations were made. The transit time to customer site was computed by taking the difference between the departure time from the preceding location and the arrival time at the customer site as reported on the LDIP (see Appendix A). In determining the transit times to the activities, there was no differentiation made between the flatbed trailer and the van. It was assumed that both vehicle types would be equally affected by any driving variables.

Table XV lists the five most variable transit times from Broadway Compound and NCA to customer sites based on the standard deviation. The third column gives the standard deviation as a percentage of the average transit time. It is noteworthy that six of the ten are to customer sites in zone eight. With access restricted to a long toll bridge, this zone is highly susceptible to delays created by traffic congestion. Since deliveries to these sites are not made at a scheduled delivery time, selection of non-rush hour times should be a consideration in order to minimize delayed transit times. For example, deliveries to North Island QUICKTRANS from NCA are performed on a daily scheduled basis at 1000 and 1300. As shown in Table XIV, the 19.7 minute average transit time is four to six minutes faster than the average transit time to other North Island customer sites.

TABLE XIV

TRANSIT TIME TO CUSTOMER SITE (in minutes)

A. FROM BROADWAY COMPOUND TO:

ACTIVITY	SAMPLE SIZE	AVERAGE TIME	STANDARD DEV	MEDIAN	NSCORE
CAMP PENDLETON	8	63.0	13.4	60.0	.816 *
NASM	12	32.2	6.8	30.0	.914 *
NRMC	10	18.8	3.2	20.0	.996
LONG BEACH	9	153.2	13.0	150.0	.964
POINT LOMA	16	20.9	5.3	20.5	.980
MCRD	-	-	-	-	-
IMPERIAL BEACH	3	25.0	5.0	25.0	1.000
NAB CORONADO	12	23.3	8.0	20.0	.977
NTC	11	16.9	2.2	16.0	.987
NASNI ANNEX	13	21.4	4.4	20.0	.973
NASNI QUICKTRANS	1	25.0	-	-	-
NASNI SERVMART	9	21.4	10.7	19.0	.925
NASNI SHIPS	13	21.2	5.0	25.0	.969
NCA SHIPS	29	20.7	8.2	17.0	.930 *
NCA (NSCSD)	51	17.9	3.6	15.0	.966 *
NCA SERVMART	29	17.1	3.1	15.0	.999

B. FROM NATIONAL CITY ANNEX TO:

ACTIVITY	SAMPLE SIZE	AVERAGE TIME	STANDARD DEV	MEDIAN	NSCORE
CAMP PENDLETON	6	64.2	9.7	62.5	.997
NASM	8	35.0	6.0	35.0	.997
NRMC	2	17.5	-	-	-
LONG BEACH	-	-	-	-	-
POINT LOMA	15	28.6	9.1	34.0	.943
MCRD	8	25.9	4.5	25.0	.990
IMPERIAL BEACH	11	24.5	3.4	25.0	.993
NTC	15	23.9	5.2	25.0	.995
NAB CORONADO	8	30.3	4.0	30.0	.985
NASNI ANNEX	7	28.6	11.4	30.0	.996
NASNI QUICKTRANS	20	19.7	3.8	20.0	.990
NASNI SERVMART	4	23.8	8.5	25.0	.992
NASNI SHIPS	12	24.5	9.5	20.0	.958
NAVELEX	13	21.5	3.8	20.0	.999
BROADWAY	100	18.2	4.8	15.0	.957

C. FROM CAL ICE

ACTIVITY	SAMPLE SIZE	AVERAGE TIME	STANDARD DEV	MEDIAN	NSCORE
NCA SHIPS	10	19.9	7.2	18.5	.968
POINT LOMA	7	22.7	8.8	20.0	.975
NAB CORONADO	1	29.0	-	-	-
NASNI SHIPS	1	16.0	-	-	-

Note: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

D. CUSTOMER SERVICE TIME

Customer service time is composed of three time periods: unload delay time, pallet unload time, and time spent at the

TABLE XV

THE MOST VARIABLE TRANSIT TIMES

A. FROM BROADWAY COMPOUND TO:

	TRANSIT TIME	STD DEV	% OF TRANSIT TIME
NASNI SERVMART	21.4	10.7	50
NCA SHIPS	20.7	8.2	39
NAB CORONADO	23.3	8.0	34
POINT LOMA	20.9	5.3	25
NASNI SHIPS	21.2	5.0	24

B. FROM NATIONAL CITY ANNEX TO:

	TRANSIT TIME	STD DEV	% OF TRANSIT TIME
NASNI ANNEX	28.6	11.4	40
NASNI SHIPS	24.5	9.5	39
NASNI SERVMART	23.8	8.5	36
POINT LOMA	28.6	9.1	32
BROADWAY	18.2	4.8	26

customer site after the pallets are unloaded. This latter time will be categorized as "other" customer service time. Examples of this would be time required for resecuring the remaining pallets on the vehicle after making a delivery to a customer; time required to perform minor emergency vehicle maintenance; or time required to perform necessary administrative functions such as obtaining signatures and verifying material delivered.

1. UNLOAD DELAY TIME

Unload delay time is that period of time from the arrival of the local delivery vehicle at the customer site until the unloading of the vehicle commences. This time was computed by taking the difference between the time unload commences and the arrival time (see Appendix A).

Table XVI lists the statistics of the unload delay time (measured in minutes) for each customer. Recognizing that several inordinate delays may significantly bias the averages, for a given customer site, those observations which were larger than two standard deviations above the

mean were considered to be outliers. Averages, standard deviations, and medians were recomputed without these outliers and are annotated in Table XVI by ***. A new NSCORE value was not computed because it would have required an excessive manipulation of the data files. If recomputed, the NSCORE value would have been higher reflecting more normalized data.

There was no distinction made in the unload delay time analysis between van or trailer deliveries since it was assumed that vehicle type was not a factor affecting unload delay time.

As shown in Table XVI, the average unload delay time per trip ranges in value from a maximum of 20.7 minutes (adjusted for outliers) for Receiving at Camp Pendleton to a minimum of 0.0 average unload delay time at NAVSEASUPCEN. Both of these times appear extreme. The zero average unload delay time at NAVSEASUPCEN may be the result of incorrectly allocating the customer service time. The extremely high average unload delay time at Camp Pendleton should be further investigated to determine any causal factors.

A factor affecting the unload delay time is the non-availability of assets to offload the vehicle. Since the material is in pallet unit loads, the normal technique for offloading is by forklift. Therefore, at most customer sites there is a delay incurred awaiting the arrival of the forklift. It would be expected that this would have the greatest impact at those customer sites that do not normally have a forklift in operation at the time of delivery vehicle arrival; for example, at the galleys and ships. Since the ships located at 32ND Street Naval Station do not have any forklift assets, NSCSD provides a forklift to the piers to assist in the offload. If this forklift is not readily available, there is a delay incurred while the ship musters a working party to manually offload the material in a manner similar to a bucket brigade.

TABLE XVI

UNLOAD DELAY TIME PER TRIP (in minutes)

ACTIVITY	SAMPLE SIZE	AVG UNLOAD DELAY TIME	STD DEV	MEDIAN	NSCORE	
CAMP PENDLETON						
RECEIVING	7	40.6	54.3	25.0	.813	*
***	6	20.7	14.5	20.0	-	
HOSPITAL	5	5.4	5.8	5.0	.938	
NAS MIRAMAR						
RECEIVING	18	5.6	4.1	5.0	.994	
***	17	5.1	3.5	5.0	-	
SERVMART	14	5.0	2.8	5.0	1.000	
GALLEY	4	16.3	14.9	15.0	.995	
NRMC	10	8.9	7.9	5.0	.937	
MCRD	9	12.1	14.6	5.0	.915	
***	8	9.1	8.4	5.0	-	
NAVELEX	16	2.8	3.6	0.0	.998	
NAVSEASYSCOM	2	0.0	0.0	0.0	-	
IMPERIAL BEACH	14	13.0	9.2	11.0	.958	
***	13	11.3	6.9	10.0	-	
NOSC	9	12.8	18.1	9.0	.752	*
***	8	6.9	3.8	7.0	-	
POINT LOMA						
GALLEY	5	4.2	4.0	5.0	.980	
SUB BASE	10	4.5	5.5	2.5	.996	
FUEL PIER	2	10.0	7.1	7.5	1.000	
PL SHIPS	45	13.2	11.7	10.0	.932	*
***	43	12.1	10.0	10.0	-	
NTC	28	12.6	11.9	10.0	.880	*
***	26	10.4	6.7	10.0	-	
LONG BEACH						
GALLEY	2	2.5	.7	2.5	1.000	
NSCSD ANNEX	6	9.5	8.5	8.5	.934	
LB SHIPS	29	4.4	4.7	3.0	.832	*
***	28	3.7	2.7	3.0	-	
NORTH ISLAND						
NSCSD ANNEX	56	7.2	9.2	5.0	.858	*
***	54	6.2	5.7	5.0	-	
SERVMART	15	5.5	4.2	5.0	.979	
***	14	4.8	3.4	5.0	-	
GALLEY	7	16.4	18.8	15.0	.897	
***	6	12.0	8.0	15.0	-	
QUICKTRANS	21	9.1	5.6	7.5	.917	*
NI SHIPS	42	9.5	11.3	5.0	.895	*
***	40	7.9	8.7	5.0	-	
NAB CORONADO						
ACU-1	7	5.0	2.5	5.0	.960	
RECEIVING	14	9.1	8.5	5.0	.906	*
***	13	7.4	5.9	5.0	-	
SERVMART	13	3.5	2.6	5.0	.958	
GALLEY	4	10.5	4.2	11.0	.987	

TABLE XVI

UNLOAD DELAY TIME PER TRIP (in minutes) cont.

ACTIVITY	SAMPLE SIZE	AVG UNLOAD DELAY TIME	STD DEV	MEDIAN	NSCORE
NCA					
SERVMART	27	8.0	7.9	10.0	.994
MTIS	43	2.1	3.8	0.0	.988
***	42	1.8	3.3	0.0	-
NSCSD	80	8.1	8.5	5.0	.926 *
***	76	6.5	6.8	5.0	-
SIMA	5	6.0	3.9	6.0	.967
PWC	7	6.3	3.0	5.0	.955
NCA SHIPS	65	8.5	7.0	5.0	.924 *
***	60	5.8	6.9	5.0	-
BROADWAY	102	7.0	7.5	5.9	.969 *
***	96	5.9	7.0	5.0	-

Note: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

Two other factors which affect the unload delay time are the requirement at some customer sites to have only designated personnel accept custody of the delivery and the time of day that the delivery is made. For example, if the delivery is made to a galley during meal preparation or serving periods, the person required to receive the provisions may not be readily available upon arrival of the delivery vehicle. This may explain the large average unload delay times in the case of provision deliveries to the galleys at NAS Miramar (average unload delay is 16.3 minutes), NAS North Island (average unload delay is 16.4 minutes), and NAB Coronado (average unload delay is 10.5 minutes).

This is one facet of the local delivery system which could benefit directly from a vehicle routing and scheduling program. Those customer sites scheduled for delivery during the day can be notified by phone in advance of the pending delivery. Ensured of delivery in a specific time period, the receiving activity can then make preparations in advance to expedite the unload of the material upon arrival of the

delivery vehicle. In addition, deliveries should be made in agreed to time windows to avoid any conflict with the ship's daily work routines.

2. "OTHER" CUSTOMER SERVICE TIME PER TRIP

"Other" customer service time is that period from completion of the unloading of material to the departure of the delivery vehicle from the customer site. This time was computed by taking the difference between the time the unload stopped and the time of departure from the customer site. As stated previously, the time required to secure the remaining pallets, backload empty pallets, and to take care of administrative matters should be reported as "other" time. However, analysis of the LDIP reports indicated that only a small percentage of the reports documented any "other" customer service time. For example, of the forty-two flatbed trailer deliveries to Point Loma, only thirteen reported "other" customer service time. Also noted was that the frequency of reporting this time varied significantly between drivers with several drivers never reporting any "other" time and other drivers reporting five minutes with each stop. There are occasions when, upon completion of the unloading of pallets, the driver can immediately leave the customer site, however, it is unlikely that this should occur only for some of the drivers and not for others. The author suspects that this "other" time is frequently erroneously included in either the transit time between sites or the time required to unload the pallets at the customer site. This would artifically inflate these times.

Table XVII lists the statistics of the "other" customer service time (in minutes) for each customer. Again, recognizing the impact of outliers on the average times, those observations more than two standard deviations

greater than the mean were disregarded, and new average, standard deviation, and median were computed and are reported as ***.

The average "other" customer service delay times are quite small but exhibit relatively high variability. As a consequence, the effect of desregarding the outliers has a negligible impact for all of the customer sites except MCRD where the average time is reduced from 9.4 minutes per trip to 3.1 minutes per trip and NCA PWC where average time was reduced from 5.1 minutes per trip to 0.0 minutes per trip.

3. UNLOAD TIME PER PALLET

Table XVIII lists the statistics associated with the the time required to unload a pallet at a customer site. This data was stratified for each customer by vehicle type if more than one vehicle type made deliveries to that customer. Those observations which were more than two standard deviations greater than the mean were treated as outliers and new average pallet unload times, standard deviations, and median were computed. The recomputed statistics are indicated in Table XVIII by ***.

As noted earlier, unload time is expected to be a function of the vehicle type; that is, it should take less time to unload a flatbed trailer than a rear entry only van. However, the data provided in Table XVIII does not necessarily support this hypothesis. This may be due to the inadequate sample size.

There are several factors which affect the variability of the average unload time. In addition to the obvious (ie., the skill of the forklift operator), there is also the physical characteristics of the customer site. Those sites which have loading dock facilities can more expeditiously unload a vehicle, especially a van, than a

TABLE XVII

OTHER CUSTOMER SERVICE TIME PER TRIP (in minutes)

ACTIVITY	SAMPLE SIZE	AVG OTHER DELAY TIME	STD DEV	MEDIAN	NSCORE
CAMP PENDLETON					
RECEIVING	7	.1	.4	0.0	1.000
HOSPITAL	5	1.0	2.2	0.0	1.000
NAS MIRAMAR					
RECEIVING	18	1.1	2.1	0.0	1.000
***	17	0.0	0.0	0.0	-
SERVMART	14	0.0	0.0	0.0	-
GALLEY	4	1.3	2.5	0.0	1.000
NRMC	10	0.0	0.0	0.0	-
MCRD	9	9.4	19.3	5.0	.785 *
***	8	3.1	3.7	2.5	-
NAVELEX	16	0.0	0.0	0.0	-
NAVSEASUPCEN	2	2.5	3.5	2.5	1.000
IMPERIAL BEACH	14	.4	1.3	0.0	.992
***	13	0.0	0.0	0.0	-
NOSC	9	.6	1.6	0.0	.998
POINT LOMA					
GALLEY	4	1.8	3.0	0.0	.955
SUB BASE	10	2.0	2.6	0.0	1.000
FUEL PIER	2	9.0	1.4	9.0	1.000
PL SHIPS	45	2.8	5.4	0.0	.877 *
***	43	1.9	2.8	0.0	-
NTC	28	.8	1.8	0.0	.987
LONG BEACH					
PWC FUEL	4	30.8	24.5	20.5	-
GALLEY	2	0.0	0.0	0.0	-
LB ANNEX	18	5.4	6.9	3.5	.924 *
LB SHIPS	29	1.8	2.4	0.0	.988
NORTH ISLAND					
NSCSD ANNEX	56	1.0	2.2	0.0	.987
SERVMART	15	1.4	4.0	0.0	.989
***	14	.4	1.3	0.0	-
GALLEY	7	.7	1.9	0.0	1.000
QUICKTRANS	21	.1	.8	0.0	.933 *
***	20	0.0	0.0	0.0	-
NI SHIPS	42	1.9	4.7	0.0	.891 *
***	40	1.0	2.0	0.0	-
NAB CORONADO					
ACU-1	7	2.1	3.9	0.0	.992
RECEIVING	14	3.2	8.0	0.0	.841 *
***	13	1.2	2.2	0.0	-
SERVMART	13	.9	1.9	0.0	.981
GALLEY	4	0.0	0.0	0.0	-
NCA					
SERVMART	27	1.6	3.7	0.0	.986
***	24	.4	1.4	0.0	-
MTIS	43	1.3	4.1	0.0	.910 *
***	41	.5	1.9	0.0	-

TABLE XVII

OTHER CUSTOMER SERVICE TIME PER TRIP (in minutes) cont.

ACTIVITY	SAMPLE SIZE	AVG OTHER DELAY TIME	STD DEV	MEDIAN	NSCORE
NCA (cont.)					
NSCSD	80	1.4	4.3	0.0	.834 *
***	78	.7	2.3	0.0	-
SIMA	5	.2	.4	0.0	1.000
PWC	7	5.1	15.8	0.0	.813 *
***	6	0.0	0.0	0.0	-
NCA SHIPS	65	2.4	3.9	1.0	.884 *
BROADWAY	102	4.8	13.9	0.0	.803 *
***	98	2.7	6.5	0.0	-

Note: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

site without. An example of this would be the high average unload times for van pier deliveries at North Island, Long Beach, and NCA compared to the average unload time at the docks at Broadway Compound.

Another factor would be the amount and location of the "laydown space" for the temporary storage of the material as it is being unloaded. If the forklift is required to make long transits from the vehicle to the laydown area, it will increase the time required to complete the unload. The Transportation Officer should evaluate the physical characteristics of each customer site and make suggestions to change their physical layout or revise their unloading procedures to improve their efficiency in order to improve his drivers pallet delivery times.

4. REGRESSION ANALYSIS OF PALLETS UNLOADED

The analysis presented in Table XVIII suggested a relationship between the number of pallets unloaded and the time for the unloading action to take place. It would appear logical that there would be a direct causal relationship between the number of pallets to unload and the time

TABLE XVIII

UNLOAD TIMES PER PALLET (in minutes)

ACTIVITY	SAMPLE SIZE	AVG UNLOAD TIME	STD DEV	MEDIAN	NSCORE
CAMP PENDLETON					
RECEIVING					
TRUCK	7	1.3	.3	1.3	.984
HOSPITAL					
TRUCK	4	1.2	1.0	1.0	.994
NAS MIRAMAR					
RECEIVING					
TRUCK	14	1.5	.7	1.5	.989
VAN	4	1.1	.3	1.0	1.000
SERVMART					
TRUCK	13	2.1	1.0	2.0	.990
VAN	1	1.0	-	-	-
GALLEY					
TRUCK	4	1.6	1.6	.8	.939
NRMC					
TRUCK	10	1.2	.3	1.1	.877 *
MCRD					
TRUCK	9	1.6	.9	1.1	.908 *
NAVSEASUPCEN					
TRUCK	2	1.5	.2	1.5	1.000
NAVELEX					
TRUCK	16	1.8	1.7	1.2	.771 *
IMPERIAL BEACH					
TRUCK	11	1.5	.9	1.1	.962
VAN	3	1.0	.0	.9	1.000
NOSC					
TRUCK	9	1.4	.9	1.0	.886 *
POINT LOMA					
GALLEY					
TRUCK	2	2.1	.6	-	-
VAN	3	5.8	2.1	6.7	.927
SUB BASE					
TRUCK	3	7.8	6.3	5.0	.924
VAN	1	8.8	-	-	-
FUEL PIER					
TRUCK	1	1.0	-	-	-
VAN	1	4.3	-	-	-
PL SHIPS					
TRUCK	29	1.9	1.0	1.4	.965
VAN	16	2.8	2.0	2.4	.909
NTC					
TRUCK	27	1.0	.5	1.0	.959
VAN	1	1.0	-	-	-
LONG BEACH					
GALLEY					
VAN	2	2.0	.1	-	-
RECEIVING					
VAN	8	1.7	1.2	2.3	.945
LB SHIPS					
VAN	29	2.4	1.3	2.0	.966

TABLE XVIII

UNLOAD TIMES PER PALLET (in minutes) cont.

ACTIVITY	SAMPLE SIZE	AVG UNLOAD TIME	STD DEV	MEDIAN	NSCORE
NORTH ISLAND					
NSCSD ANNEX					
TRUCK	56	2.1	1.6	1.7	.872 *
SERVMART					
TRUCK	15	2.0	1.4	1.6	.919 *
QUICKTRANS					
TRUCK	21	.8	.3	.8	.988
GALLEY					
TRUCK	2	1.7	.6	-	-
VAN	4	2.4	1.3	2.4	.955
NI SHIPS					
TRUCK	38	2.8	2.7	1.7	.877 *
VAN	4	2.3	1.0	2.3	1.000
NAB CORONADO					
ACU-1					
TRUCK	2	3.8	-	-	-
VAN	5	3.7	2.2	2.5	.957
RECEIVING					
TRUCK	11	2.0	1.3	1.4	.927
VAN	3	1.0	0.0	1.0	1.000
SERVMART					
TRUCK	13	3.4	2.6	2.5	.925
GALLEY					
TRUCK	3	1.6	.8	1.4	.987
VAN	1	2.5	-	-	-
NCA					
SERVMART					
TRUCK	20	.9	.4	.8	.971
VAN	7	.9	.1	1.0	1.000
MTIS					
TRUCK	23	1.7	1.9	1.3	.667 *
NSCSD					
TRUCK	75	1.2	.7	1.1	.894 *
VAN	5	2.5	4.2	.8	.810 *
SIMA					
TRUCK	5	1.2	1.2	.4	.995
PWC					
TRUCK	7	1.3	.3	1.3	.994
NCA SHIPS					
TRUCK	7	1.1	.2	1.0	.889
VAN	58	3.2	3.0	1.7	.987
BROADWAY					
TRUCK	84	1.2	.9	1.1	.781 *
VAN	18	1.5	1.8	.9	.944

Note: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

required to accomplish this action. This relationship when identified could then be used as a predictor for determining the time required to unload a given number of pallets at a

customer site. By quantifying this relationship and including it into a vehicle routing and scheduling algorithm, the accuracy of average unloading schedule times should increase.

Regression analysis was performed to predict the dependent variable of time to unload pallets from the independent variable of a given number of pallets. Linear, exponential, power, and logarithmic regressions were evaluated using the coefficient of determination, or the square of the correlation coefficient R, as the measure of the proportion of the total variation explained by the regression. The value of the coefficient of determination for the linear model was equal to or better than most of the other models and was not significantly (less than eleven percent) inferior than the best non-linear regression for any customer site. For the linear model, Table XIX lists the Y-intercept, slope, R-square value, and standard deviation of Y about the regression line for each major customer site. The R-square values range from a high of 0.99 to a low of 0.02.

In general, those customer sites where the unload time is strongly correlated to the number of pallets unloaded (R-square approaches one) have the smallest Y-intercept values and vice versa. Where there is a weak correlation between the number of pallets unloaded and the unload time, there are other variables which are significantly affecting the unload time. Examples of this would be varying abilities of forklift operators, the amount of supervision in the unload operation, or the time of day of delivery (unloading would be expedited so that it would not overlap with break periods or quitting time).

The negative slopes are unexpected and imply that there is an inverse relationship between the number of pallets unloaded and the time required to unload them. That

TABLE XIX

PALLET UNLOADING TIME REGRESSION ANALYSIS

ACTIVITY	Y-INTERCEPT (minutes)	SLOPE (minutes)	R-SQUARE	STD DEV OF Y|X (minutes)
CAMP PENDLETON				
RECEIVING				
TRUCK	5.24	.871	.80	5.283
HOSPITAL				
TRUCK	15.30	.230	.02	21.570
NAS MIRAMAR				
RECEIVING				
TRUCK	16.60	.268	.08	8.292
VAN	3.33	.833	.76	2.887
SERVMART				
TRUCK	5.41	1.120	.75	5.519
GALLEY				
TRUCK	-10.90	2.520	.87	9.477
NRMC				
TRUCK	15.20	.510	.24	9.393
MCRD				
TRUCK	5.85	.849	.75	6.625
NAVELEX				
TRUCK	10.30	.390	.32	3.980
IMPERIAL BEACH				
TRUCK	88.60	-1.670	.27	16.910
VAN	.96	.913	.99	.981
NOSC				
TRUCK	-5.85	1.540	.69	13.740
PT LOMA				
GALLEY				
VAN	-27.00	14.00	.72	7.071
SUB BASE				
TRUCK	10.80	2.080	.21	11.490
PL SHIPS				
TRUCK	12.20	.718	.33	11.580
VAN	11.80	1.040	.41	12.450
NTC				
TRUCK	8.39	.552	.32	8.664
LONG BEACH				
RECEIVING				
VAN	8.75	-.156	.13	5.929
LB SHIPS				
VAN	5.34	1.180	.35	6.759
NORTH ISLAND				
NSCSD ANNEX				
TRUCK	7.12	.591	.37	6.299
SERVMART				
TRUCK	8.28	.549	.47	6.114
QUICKTRANS				
TRUCK	10.10	.430	.26	6.479

TABLE IXX

PALLET UNLOADING TIME REGRESSION ANALYSIS (cont.)

ACTIVITY	Y-INTERCEPT (minutes)	SLOPE (minutes)	R-SQUARE	STD DEV OF Y|X (minutes)
NORTH ISLAND (cont.)				
GALLEY				
VAN	18.10	.785	.18	17.810
NI SHIPS				
TRUCK	8.36	.518	.48	5.819
VAN	22.30	.685	.07	18.810
NAB CORONADO				
ACU-1				
VAN	4.66	.979	.72	1.548
RECEIVING				
TRUCK	5.37	.818	.33	5.777
SERVMART				
TRUCK	2.03	2.210	.32	5.082
GALLEY				
TRUCK	4.30	.695	.99	1.094
NCA				
SERVMART				
TRUCK	10.60	.454	.32	9.669
NSCSD				
TRUCK	4.71	.741	.47	8.143
VAN	12.00	-.135	.05	6.910
SIMA				
TRUCK	7.65	.597	.60	6.526
PWC				
TRUCK	11.60	.256	.02	11.700
NCA SHIPS				
TRUCK	-6.62	1.410	.84	6.972
VAN	7.67	1.200	.59	7.822
BROADWAY				
TRUCK	5.24	.712	.37	7.951
VAN	9.28	-.139	.02	10.140

is, as more pallets are unloaded, less time is required to unload them. A negative Y-intercept is also not expected. This implies that for some small quantities of pallets unloaded, there would be zero or negative unloading time. For those activities with a negative Y-intercept, a model other than the linear model should be used as a predictor of unloading time. Those activities with negative slopes and Y-intercepts should be studied further to identify the factors actually affecting unload times.

E. SUPPLY CENTER LOADING TIME

Supply Center loading time is comprised of three elements: loading delay time, "other" loading delay time, and pallet loading time. Similar to "other" customer service time, "other" loading delay time is that time spent at the loading site not classified as loading delay time or loading time. It would include such periods as administration, vehicle safety checks, and meetings.

1. LOADING DELAY TIME

Table XX lists the statistics for the loading delay time (in minutes) for the NSCSD locations that loaded the delivery vehicles. This time was computed by determining the difference between the arrival time at a loading location and the time that loading commenced. Those records with a loading delay time greater than two standard deviations from the mean were considered as outliers and were computed with those records disregarded. The recomputed activities are indicated on Table XX by ***.

The high average loading delay times listed, as compared to previous tables average times, can be attributed to several factors. Although NSCSD attempts to preload the vehicles prior to the drivers reporting for work, this cannot always be accomplished and a queue results as the drivers wait for the loading of their vehicles. The effect of preloading is most evident at CAL ICE where the average loading delay time is twenty-one minutes. There is no preloading at CAL ICE and NSCSD drivers must queue with commercial drivers. In contrast, the average van loading delay time for Broadway Compound is 4.8 minutes and the provisions are preloaded on the vehicles prior to the arrival of the drivers.

Another factor affecting the loading delay time is the problem of reporting that was addressed previously in the allocation of time between unloading delay time and "other" customer service time. Time allocated to administrative matters and road checking the vehicle should be reported as "other" loading delay time rather than loading delay time. The author attempted to make this distinction in his analysis of the LDIP reports when there was an obvious erroneous reporting of the allocation of the time. However, since this distinction was not apparent in all LDIP reports, the author suspects that the average load delay time may be inflated.

TABLE XX

LOADING DELAY TIME PER TRIP (in minutes)

ACTIVITY	SAMPLE SIZE	AVG LOAD DELAY TIME	STD DEV	MEDIAN	NSCORE
BROADWAY					
TRUCK	139	16.8	21.4	10.0	.887 *
***	133	9.3	8.2	8.5	-
VAN	35	5.4	7.5	0.0	.969
***	34	4.8	6.8	0.0	-
NCA					
TRUCK	193	10.8	14.0	6.0	.861 *
***	187	8.4	9.2	6.0	.967
VAN	8	7.6	6.6	6.5	.967
CAL ICE					
VAN	10	26.9	24.9	18.5	.918
***	9	21.0	17.5	17.0	-
NORTH ISLAND					
NSCSD ANNEX					
TRUCK	8	6.5	5.6	7.5	.990
VAN	3	3.3	2.9	5.0	1.000
QUICKTRANS					
TRUCK	22	11.1	13.3	5.0	.884 *

Note: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

2. "OTHER" LOADING DELAY TIME

Table XXI lists the average "other" loading delay time in minutes for the NSCSD locations that loaded the delivery vehicles. This time was computed by taking the difference between the time that the loading of pallets was completed until the departure of the vehicle from the loading location. In addition, any time that was reported as being administrative or, in the author's opinion, was not related to loading delay time was also added to the "other" loading delay time. This would include those periods of time at driver safety meetings and vehicle inspections.

A factor affecting the "other" loading delay time is the delay in providing drivers and warehousemen with their initial daily work assignments. Although the normal work day commences at 0700, there is a delay until actual productivity begins in the form of loading the trailers or departing the Supply Center with preloaded vehicles. It is during this time that minor administrative matters are completed. A possible indication of this delay is the difference between average "other" loading delay times between North Island Annex and Broadway Compound and NCA. For those reports analyzed in the study, loading at North Island Annex was performed during the course of the day well after the initial work assignments had been made. As a result, the average "other" loading delay time at North Island Annex does not reflect this initial assignment delay and is significantly less than van and truck "other" loading delay times at Broadway Compound and truck "other" loading delay times at NCA.

TABLE XXI

OTHER LOADING DELAY TIME (in minutes)

ACTIVITY	SAMPLE SIZE	AVG OTHER DELAY TIME	STD DEV	MEDIAN	NSCORE
BROADWAY					
TRUCK	139	12.8	18.1	5.0	.914 *
***	133	10.4	13.2	5.0	-
VANS	35	12.2	17.8	5.0	.866 *
***	33	8.7	10.2	5.0	-
NCA					
TRUCK	193	9.9	17.5	3.0	.863 *
***	187	6.6	11.4	3.0	-
VAN	8	3.1	3.7	2.5	.999
CAL ICE					
VAN	10	10.1	11.5	5.0	1.000
NORTH ISLAND					
NSCSD					
TRUCK	8	0.0	0.0	0.0	-
VAN	3	3.3	2.9	5.0	1.000
QUICKTRANS					
TRUCK	22	5.8	12.0	0.0	.911 *
***	21	3.8	8.4	0.0	-

Note: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

3. PALLET LOADING TIME

Table XXII lists the statistics for the loading time per pallet (in minutes). Again, samples greater than two standard deviations from the mean were considered outliers and were disregarded in the new computations for the activities. These are indicated by ***.

Loading time per pallet, like that of unloading time, is a function of the forklift driver's ability and the physical characteristics of the loading site.

The North Island Annex of NSCSD has an average loading time per pallet for trucks which is thirty-nine percent less than that of NCA and forty-five percent less than that of Broadway Compound. In addition, its van average loading time is eleven percent and fifteen percent less than that of NCA and Broadway Compound, respectively.

This difference, especially in the truck loading times, may be a factor of the small sample size, or it may be attributed to the time of day that the loading was accomplished. That is, the loading at North Island may occur during slack periods from material prestaged adjacent to the loading dock. CAL ICE also has a loading time per pallet the same as that of North Island Annex. Because of the large difference in average loading times between CAL ICE/North Island and Broadway Compound/NCA, the cause of this difference should be determined for possible application in reducing overall NSCSD pallet loading times.

TABLE XXII

LOADING TIME PER PALLET (in minutes)

ACTIVITY	SAMPLE SIZE	AVG LOAD TIME	STD DEV	MEDIAN	NSCORE
BROADWAY					
TRUCK	139	2.1	1.1	1.9	.963 *
***	134	2.0	.8	1.8	-
VAN	35	2.1	1.2	1.7	.950 *
***	33	1.9	1.0	1.7	-
NCA					
TRUCK	193	2.1	1.4	1.7	.850 *
***	190	1.8	.9	1.7	-
VAN	8	2.2	1.5	1.8	.943
CAL ICE					
VAN	10	1.6	.6	1.6	.987
NORTH ISLAND					
NSCSD ANNEX					
TRUCK	8	1.1	.6	1.0	.938
VAN	3	1.6	.4	1.7	.998
QUICKTRANS					
TRUCK	22	2.4	2.0	2.1	.831 *
***	21	2.1	1.1	2.0	-

Note: The asterisk (*) indicates that the probability plot correlation has failed the test for a normal distribution at the five percent level (see Appendix C).

4. REGRESSION ANALYSIS OF PALLETS LOADED

Similar to the regression analysis conducted between pallets unloaded and unload time, a regression analysis was conducted of pallet loading time as a function of the number of pallets loaded at NSCSD's primary loading sites. Again, the intent was to determine if there was a strong statistical relationship between these two variables in order that the number of pallets to be loaded could be used as a predictor of pallet loading time. The linear model was at least as good as any non-linear model. The statistics from the linear regression are provided in Table XXIII.

With the exception of the North Island NSCSD Annex van loading times, there is a weak correlation between loading times and the number of pallets loaded. This implies that variables other than the number of pallets loaded are significantly influencing the loading time.

TABLE XXIII

PALLET LOADING TIME REGRESSION ANALYSIS

ACTIVITY	Y-INTERCEPT (minutes)	SLOPE (minutes)	R-SQUARE	STD DEV OF Y|X (minutes)
BROADWAY				
TRUCKS	20.60	1.100	.17	21.220
VANS	9.47	.989	.47	15.610
NCA				
TRUCKS	11.10	1.210	.28	19.390
VANS	10.40	.621	.58	5.566
CAL ICE				
VANS	1.21	1.540	.42	13.920
NORTH ISLAND				
NSCSD				
TRUCK	12.00	.220	.05	6.713
VAN	-3.33	2.500	.75	2.041
QUICKTRANS				
TRUCK	1.43	1.840	.47	26.320

V. SUMMARY AND RECOMMENDATIONS

A. SUMMARY

The costs associated with operating vehicles and material handling equipment for local delivery purposes comprises a significant portion of a Supply Center's operating costs. A small percentage of savings in vehicle rental costs coupled with reduced labor costs through reductions in overtime and commercial drayage charges would justify efforts to improve the efficiency of the current local distribution system.

The use of analytic routing and scheduling models can be instrumental in improving the efficiency of a local distribution system and achieving these savings. Automated vehicle scheduling programs for local distribution systems have been shown to be workable at Navy Supply Centers. The VSP program used previously at NSCSD and the AVS program in current use on a limited basis at NSC Charleston are two examples. However, a major deficiency in these two systems has been the inability to develop a method of automating the input of the data. With the development of NISTARS and NAVADS, the data input problem may be solvable and an automated vehicle scheduling program may be practical for increasing the local delivery system's efficiency and effectiveness.

In order to develop an automated local delivery routing/scheduling system, some specific data is required. These requirements are:

1. fleet size and capacity
2. delivery vehicle loading time
3. transit time to customer sites

4. customer service time

5. volume of material delivered

Utilizing the LDIP reports for the month of July, 1982, this thesis determined these requirements. More specifically, the following information was obtained:

1. statistics for the loading time per pallet by vehicle type (van versus trailers) at NSCSD's primary loading sites.

2. statistics for loading delay time per trip by vehicle type at NSCSD's primary loading sites. This loading delay time was further stratified between time spent awaiting the commencement of loading the pallets, and any "other" driver time at the loading site not associated with loading the vehicle.

3. statistics for the unloading time per pallet by vehicle type at each major customer site.

4. statistics for service time per trip at each major customer site. This time consisted of unloading delay time which was the time awaiting the unload to commence and "other" vehicle unload delay time which was the time from completion of the unload until the vehicle left the customer site.

5. statistics for transit times from Broadway Compound, NCA, and CAL ICE to major customer sites.

6. statistics for volume of material delivered to major customer and delivery zone by trailer and van.

B. RECOMMENDATIONS

As stated in Chapter 1, the purpose of this thesis was to conduct a study of the local delivery distribution system at NSCSD in an attempt to develop a data base for use in a truck routing and scheduling algorithm to optimize the use of personnel and local delivery vehicle assets. The recommendations in the following paragraphs are made to further enhance the results of this study.

The format of the LDIP report presently in use is adequate for documenting the information required for a truck routing and scheduling algorithm. However, there are several coding deficiencies that if corrected would improve upon the accuracy of the information collected:

1. There is no differentiation between 40 and 42-foot trailers and vans. This is required for

determination of vehicle capacities and measurement of loading efficiency. It is recommend that the vehicle type legend code be updated to accurately reflect vehicle types presently utilized.

2. There is no consistency in the manner in which the drivers are reporting the "other" customer service and loading delay times. Failure to report this information in a consistent manner limits management's ability in evaluating the performance of their personnel in terms of productive time versus non-productive time.

3. For approximately fifty percent of the reports analyzed, time of lunch break was not indicated, or if indicated, conflicted with other activity times reported. Recognizing that a flexible lunch schedule as dictated by each drivers' activities is a necessity, accurately documenting the lunch period taken is needed to properly allocate the drivers time at each site.

The Compound Driver Performance Record utilized by pallet transporter and straddle truck operators is inadequate for documentation of customer deliveries for a vehicle routing scheduling algorithm at NCA. If the Transportation Department management determines that it is impractical for the straddle truck operators to document transit times, loading and customer service times, then it is recommended that a study be conducted to determine these standards, or some type of automatic recording system be obtained. This is presently under consideration by the Transportation Officer.

The problem of using a pallet as a work measurement unit was addressed by Eller and Moore [Ref. 6] and still persists. Measurements by actual pallet count are the easiest to maintain. However, the procedure of having the driver estimate his load in measurement tons or cubic feet in order to adjust for partial pallet loads does not lend itself to consistent quantity reporting. Rather than have the driver attempt to make this conversion from actual pallet count to a reported standard pallet count, statistical sampling should be performed by knowledgeable analysts. A conversion factor could then be developed to be applied to the actual number of pallets carried based on the type of material (ie., GSK or provisions).

Because of time constraints, analysis could not be performed on the deliveries made by those vehicles classified as category two in Chapter Four (ie., stake trucks and pickups trucks). It is recommended that a study be conducted to determine transit, loading and customer service times for each customer site similar to that conducted in this study. Also, additional data should be collected and analyzed for those customer sites analyzed where the volume of data for the month of July was insufficent to provide meaningful statistics.

Finally, those sites where the regression analysis of unloading times showed low R-square values or negative slopes should be studied further to identify the factors actually affecting the unloading times.

APPENDIX A

LOCAL DELIVERY INDIVIDUAL PRODUCTION REPORT

LOCAL DELIVERY INDIVIDUAL PRODUCTION REPORT
NSC-[illegible] (Rev. 9-81) Driver: ______ Vehicle #'s: truck ______ trailer ______ Odometer reading Start ______ Finish ______ Date ______

	*TYPE VEHICLE	*TYPE MATERIAL	*DESTINATION	[illegible]	*ARRIVAL TIME	[illegible]	*TIME UNLOAD BEGINS	[illegible]	*TIME UNLOAD STOPS	*PALLETS OFF STORES	*PALLETS OFF [illegible]	[illegible]	*TIME LOADING BEGINS	*DEPARTURE TIME	*PALLETS LOADED	*PALLETS ON BOARD	[illegible]	*LOADER'S I.D. OR NAME	*REMARKS
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
*To be filled in by driver									*TOTAL PALLETS DELIVERED				*TOTAL PALLETS LOADED						

TYPE VEHICLE	TYPE MATERIAL	REMARKS	BREAKS
A - 40' FLAT B - 32' FLAT C - 7.5T STAKE D - 5T STAKE E - 2.5T STAKE F - 15T P/U G - .75T P/U H - 40' VAN I - 36' VAN J - 5T VAN K - 40' REEFER L - 35' REEFER M - 30' REEFER N - 5' REEFER O - STRADDLE TRUCK	GSK - GENERAL SUPPLIES STL - STEEL DRY - DRY PROVISIONS FRZ - FREEZE CHL - CHILL PLT - PALLET	A - NO FORKLIFT B - NO WORK PARTY C - NO CRANE D - PIER BLOCKED E - PIER CLOSED F - REJECTION G - MECHANICAL PROBLEMS	FROM / TO AM ______ ______ LUNCH ______ ______ PM ______ ______

APPENDIX B

AUTOMATIC VEHICLE SCHEDULING (AVS) PROGRAM SCHEDULES

The AVS program was developed by the David W. Taylor Naval Ship Research and Development Center for use at NSC Charleston as a local delivery vehicle routing/scheduling system. The following description and figures are intended to supplement the information provided in Chapter 3.

Included in the AVS program data base is information peculiar to the Supply Center that is using the program. This information would include transit times between various locations and loading/unloading times for each vehicle. This information is utilized with the daily delivery requirements data that is provided by the dispatcher in the development of the vehicle schedules.

Figures B.1 through B.5 are examples of regular schedule output generated by the AVS program. Figures B.6 through B.9 are examples of emergency schedule output.

The scheduling procedure is initiated by the warehousemen when they notify the dispatcher of the number of pallets that they have available for delivery and their respective destinations. The dispatcher then enters this data by means of a CRT terminal to the AVS program. Figure B.1 is an example of the data entered. For example, order one is five pallets from Building 191 to be delivered to Building 1601A. Order two is two pallets from Building 191 to be delivered to Building 1601B.

1	5	PAL	191	TO	1601A	
2	2	PAL	191	TO	1601B	
3	7	PAL	191	TO	1605	
4	2	PAL	53C	TO	64E	
5	4	PAL	53C	TO	1622	
6	6	PAL	98	TO	1013	
7	5	PAL	98	TO	1174	
8	7	PAL	30	TO	193	
9	10	PAL	30	TO	45	
10	20	PAL	1605	TO	193	
11	20	PAL	1605	TO	43S	
12	20	PAL	43S	TO	1605	
13	18	PAL	43S	TO	193	

FIGURE B.1 ORDERS

After input of the delivery requirement data, the dispatcher then enters the vehicles available for scheduling. These vehicles are assumed to originate and terminate at the same location. Figures B.2 through B.5 are examples of schedules generated to deliver the orders listed in Figure B.1. Figure B.2 is the schedule for straddle truck 1. The dispatcher has entered into the AVS program that the straddle truck's load capacity is five pallets; the duration of its schedule is not to exceed 240 minutes; and the vehicle is to depart the point of origin at 0800.

Straddle truck 1 completes its route at time 1050 at Building 1078. There are still 70.8 minutes available of the 240 minutes originally specified. This is the result of all of the pallets, that were reported available for delivery, having either been delivered or scheduled for delivery by other vehicles. During its schedule, thirty-four pallets are delivered, and orders one, two, four, five, six, seven, and nine are completed.

Figure B.3 is the schedule for transporter vehicle 1. It has a load capacity of ten pallets.

Schedules are provided in Figures B.4 for tractor trailer 1 and in Figure B.5 for tractor trailer 2. The combined schedules of these vehicles, as shown in Figures B.2 through B.5, completed the delivery requirements of Figure B.1.

VEHICLE - ST1
CAPACITY - 5 PALLETS
TIME LIMIT - 240 MINUTES
START TIME - 800
DATE - 7/23/82

STOP	SITE	TIME	DELIVER	PICK UP	ORDER	STAY
1	30	820		5 PALLETS	9	3
2	45	843	5 PALLETS			3
3	98	855		5 PALLETS	7	3
4	1174	859	5 PALLETS			3
5	98	904		1 PALLETS	6	2
6	1013	908	1 PALLETS			2
7	98	912		5 PALLETS	6	3
8	1013	917	5 PALLETS			3
9	30	933		5 PALLETS	9	3
10	45	956	5 PALLETS			3
11	53C	1001		2 PALLETS	4	2
12	64E	1005	2 PALLETS			2
13	53C	1009		4 PALLETS	5	3
14	1622	1020	4 PALLETS			3
15	191	1025		5 PALLETS	1	3
16	1601A	1030	5 PALLETS			3
17	191	1034		2 PALLETS	2	2
18	1601B	1038	2 PALLETS			2

ROUTE FINISHED AT 1050
LOCATION = 1073
TIME LEFT = 70.8 MINUTES
PALLETS MOVED = 34

FIGURE B.2 STRADDLE TRUCK 1 SCHEDULE

1. The schedule generated for straddle truck 1 has it making its first stop at Building 30 at time 0820. There it picks up five pallets (partial pickup of delivery requirement) of order nine (see Figure B.1). Load time is three minutes.

2. Stop 2 is at Building 45 at scheduled time 0843. Here the five pallets are dropped and the unload time is three minutes.

3. The next stop is Building 98 at scheduled time 0855. Here five pallets of order seven are picked up in a scheduled load time of three minutes.

4. These are then delivered to Building 1174 ....

VEHICLE - TR1
CAPACITY - 10 PALLETS
TIME LIMIT - 240 MINUTES
START TIME - 800
DATE - 7/23/82

STOP	SITE	TIME	DELIVER	PICK UP	ORDER	STAY
1	191	807		7 PALLETS	3	8
2	1605	817	7 PALLETS	10 PALLETS	11	16
3	43S	900	10 PALLETS	10 PALLETS	12	18
4	1605	946	10 PALLETS	10 PALLETS	11	18
5	43S	1031	10 PALLETS	10 PALLETS	12	18
6	1605	1117	10 PALLETS			10

ROUTE FINISHED AT 1134
LOCATION = 1078
TIME LEFT = 26.6 MINUTES
PALLETS MOVED = 47

FIGURE B.3 TRANSPORTER VEHICLE 1 SCHEDULE

1. Transporter vehicle 1 is to make its first stop at Building 191 and pickup seven pallets of order three. Load time for this stop is eight minutes.

2. It delivers these pallets to Building 1605 at time 0817. After unloading the seven pallets, it loads ten pallets of order eleven. Total stay time at Building 1605 is 16 minutes.

3. It then continues on with the remainder of its schedule.

VEHICLE - TT1
CAPACITY - 14 PALLETS
TIME LIMIT - 240 MINUTES
START TIME - 800
DATE - 7/23/82

STOP	SITE	TIME	DELIVER	PICK UP	ORDER	STAY
1	1605	809		14 PALLETS	10	29
2	193	901	14 PALLETS			29
3	30	939		7 PALLETS	8	17
4	43S	958		4 PALLETS	13	12
5	193	1019	11 PALLETS			24
6	43S	1051		14 PALLETS	13	29
7	193	1129	14 PALLETS			29

ROUTE FINISHED AT 1210
LOCATION = 1078
TIME LEFT = -9.6 MINUTES
PALLETS MOVED = 39

FIGURE B.4 TRACTOR TRAILER 1 SCHEDULE

VEHICLE - TT2
CAPACITY - 14 PALLETS
TIME LIMIT - 240 MINUTES
START TIME - 800
DATE - 7/23/82

STOP	SITE	TIME	DELIVER	PICK UP	ORDER	STAY
1	1605	809		6 PALLETS	10	16
2	193	848	6 PALLETS			16

ROUTE FINISHED AT 915
LOCATION = 1078
TIME LEFT = 165.6 MINUTES
PALLETS MOVED = 6

FIGURE B.5 TRACTOR TRAILER 2 SCHEDULE

In the event of an emergency issue, ie. an IG 1 requirement, the dispatcher would enter this information into the AVS program as shown in Figure B.6. MIX = 1 indicates that the dispatcher has determined that more than one vehicle type may be used to fill the order. PROPT = 1 indicates that the dispatcher has determined that non-emergency orders may be bumped to fill this order.

Figure B.7 is an example of the AVS response to the emergency requirement provided to the dispatcher. From this vehicle availability menu, he can then select the vehicles that he wants to utilize to fill the delivery requirement. His response as indicated in Figure B.7 is transporter vehicle 1 and transporter vehicle 2. Their schedules are then modified as indicated in Figures B.8 and B.9.

```
AVS EMERGENCY ORDER PROGRAM

---------------------------------

   DATE  - 7/24/82
  SHIFT  - 800
   TIME  - 945
   SIZE  _ 15 PALLETS
   FROM  = 193
     TO  - 1171

   (MIX  = 1)
 (PROPT  = 1)
```

FIGURE B.6 EMERGENCY ORDER REQUIREMENT

```
VEHICLE AVAILABILTY

-------------------

ST1  AVAILABLE AT   959. / 45
ST2  AVAILABLE AT   945. / 1078
ST3  AVAILABLE AT   945. / 1078
TR1  AVAILABLE AT   945. / 1078
TR2  AVAILABLE AT   945. / 1078
TR3  AVAILABLE AT   945. / 1078
TT1  AVAILABLE AT   951. / 1605
TT2  AVAILABLE AT  1028. / 1078

SPECIAL ORDER ASSIGNED TO THE FOLLOWING VEHICLES

------------------------------------------------

----  1  TR1
----  2  TR2
```

FIGURE B.7 VEHICLE AVAILABILITY MENU

VEHICLE - TR1
CAPACITY - 12 PALLETS
TIME LIMIT - 240 MINUTES
START TIME - 800
DATE - 7/24/82

STOP	SITE	TIME	DELIVER	PICK UP	ORDER	STAY
1	191	807		7 PALLETS	3	8
2	1605	817	7 PALLETS			8
3	1078	823				
		***** SPECIAL ORDER *****				
4	193	1005		12 PALLETS	1	12
5	1171	1023	12 PALLETS			12

ROUTE FINISHED AT 1041
LOCATION = 1078
TIME LEFT = 79.4 MINUTES
PALLETS MOVED = 19

FIGURE B.8 TRANSPORTER VEHICLE 1 SCHEDULE

VEHICLE - TR2
CAPACITY - 12 PALLETS
TIME LIMIT - 240 MINUTES
START TIME - 800
DATE - 7/24/82

STOP	SITE	TIME	DELIVER	PICK UP	ORDER	STAY
			***** SPECIAL ORDER *****			
1	193	1005		3 PALLETS	1	4
2	1171	1015	3 PALLETS			4

ROUTE FINISHED AT 1027
LOCATION = 1078
TIME LEFT = 93.8 MINUTES
PALLETS MOVED = 3

FIGURE B.9 TRANSPORTER VEHICLE 2 SCHEDULE

APPENDIX C

Probability Plot Correlation Coefficient Test

J. Filliben developed the Probability Plot Correlation Coefficient Test as a test of normality. The test determines the "straightness" of the probability plot as measured by the correlation coefficient of the points in the plot. A high correlation is consistent with normality, therefore, a computed NSCORE less than a critical value, alpha, will cause rejection of the null hypothesis that the sample was taken from a normal distribution. The Table XXIV lists the critical NSCORE values for the left-hand tail test for various sample sizes and alpha risk levels.

TABLE XXIV

NSCORE NORMALITY TEST VALUES

SAMPLE		ALPHA	
SIZE	.01	.05	.10
5	.822	.879	.902
10	.876	.917	.934
15	.907	.937	.950
20	.925	.950	.960
25	.937	.958	.966
30	.947	.964	.970
35	.952	.968	.974
40	.958	.972	.977
45	.961	.974	.978
50	.965	.977	.981
55	.967	.978	.982
60	.970	.980	.983
65	.972	.981	.984
70	.974	.982	.985
75	.975	.983	.986
80	.976	.984	.987
85	.977	.985	.987
90	.978	.985	.988
95	.979	.986	.989
100	.981	.987	.989

[illegible]

LIST OF REFERENCES

1. Defense Logistics Analysis Office; An Appraisal of the Joint Logistics Commanders' DOD Material Distribution System (DODMDS) Study Volume I, August 1978.

2. U.S. Department of Defense, Joint Logistics Commanders; DOD Material Distribution System Study, Volume II, 1 July 1978.

3. Gallo, C. and Carpenter, R.; "Aviation Wholesale Supply Support Consolidation." Navy Supply Corps Newsletter, July 1980.

4. Sperry Division Systems Management; Functional Description of the Navy Integrated Storage Tracking and Retrieval System, prepared for Naval Supply Systems Command under contract N00228-80-C-UQ06.

5. Allion, Dennis G. and Tufts, John J.; An Analysis of Local Delivery Costs and Times at Naval Supply Center Oakland, California Master's Thesis, Naval Postgraduate School, Monterey, California, June 1982.

6. Eller, Jeffrey M. and Moore, Robert T; Analysis of Material Distribution from NSC San Diego to Local Customers, Master's Thesis, Naval Postgraduate School, Monterey, Ca., September 1981.

7. Naval Supply Center, San Diego; Customer Service Manual, NSCINST P4000.1C, 28 June 1976

8. Naval Supply Center, San Diego Memorandum, 041.4:cw(4049) itd 11 March 1982 to Commanding Officer, Naval Supply Center, San Diego, Subject: Local Drayage at Naval Supply Center, San Diego.

9. Office of the Chief of Naval Operations; OPNAV Instruction 4614.1E, Uniform Material Movement and Issue Priority System (UMMIPS), 19 January 1977.

10. Naval Supply Center, San Diego; Report of Workload and Program Trends, Code 303, July 1982.

11. Gibfried, Charles P.; "Computer Controlled Transportation", The Navy Supply Corps NEWSLETTER, July 1972.

12. Naval Supply Center, San Diego; Local Delivery Study, Planning Department, Advance Planning Division, Analysis Branch, April 1981.

13. Clausen, Clifford D.; Vehicle Routing Algorithms for Local Delivery at Naval Supply Centers, Master's Thesis, Naval Postgraduate School, Monterey, CA. March 1981.

14. Telephone interview with Mr. R. W. Farley, Code 407, Naval Supply Center, Charleston, South Carolina, 10 November 1982.

15. Navy Fleet Material Support Office; Navy Automated Transportation Documentation System (NAVADS) Requirements Statement, FMSO Document no. NAVADS RS-01, 28 February 1978.

16. Bodin, L., and others; The State of the Art in the Routing and Scheduling of Vehicles and Crews, working paper MS/S #81-035, July 1982.

17. Telephone interview with LCDR R. Kiggins, Transportation Officer, Naval Supply Center, San Diego, Ca., 16 November 1982.

18. Filliben, J. J., "The Probability Plot Correlation Coefficient Test For Normality", Technometrics, Vol 17, 1975.

19. Lapin, Lawrence L., Statistics, Meaning and Method Harcourt, Brace, Jovanovich, Inc., 1975

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